THE HAWAIIAN PLANTERS' RECORD

Volume XXXI. JANUARY, 1927 Number 1

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Some Notes on Irrigation at the Waipio Substation

By J. A. VERRET and F. C. DENISON

These notes cover some studies made on water measurements, the object being to get some data on the amounts of water used per day and the acre inches applied per acre by individual irrigators.

The measurements were made at the watercourse by means of V notch weirs. Such measurements are accurate to possibly within 5 per cent. In some cases the error may be greater than this. The portable weirs were placed in the head of each watercourse on a level ditch. We endeavored to eliminate all velocity of approach and to have a good still pond, but, especially in big canes, this was very difficult. Measurements of the head passing over the weirs were made every half hour, and the time required to complete the watercourse by the irrigator was carefully noted.

The flow being used by the irrigator when the weir was put in was kept as constant as possible during the test, that is, the irrigator was not allowed to speed up while being checked.

SUPPLY AND LEVEL DITCH LOSSES

In obtaining these data we measured the water with a Great Western meter as it entered the supply ditch and checked this amount against the quantities shown in the watercourse. The average distance from intake to average watercourse was approximately 2,000 feet. The work was in cane 16 months old and 28 days since previous irrigation. The irrigators were using 159,670 gallons of water per day as measured at the supply ditch meter. Water was being applied at the rate of 6.35 acre inches per acre measured at the watercourse, or 7.8 inches when measured at supply ditch meter. In this case the loss between supply ditch

intake and the watercourse was found to be 19 per cent. The following is a summary:

Total water measured at supply ditch	1.890 ac. ft. =	615,858 gallons
Total water measured at watercourses......	1.527 ac. ft. =	497,574 gallons
Loss..............................	.363 ac. ft. =	118,284 gallons

Per cent loss = 19 per cent.

Water Applied per Acre and Per Man Day

Our measurements were made in seven different fields with cane varying from seven to sixteen months of age.

Field	Age of Cane	Crop	Days Since Previous Irrigation	Acre Inches Per Acre At Source	Acre Inches Per Acre At W. C.	Gallons Per Man Day At Source	Gallons Per Man Day At W. C.	Acres Per Man Day
J and K	16	Fourth ratoons	28	7.38	6.35	147,120	119,160	0.69
J	16	Fourth ratoons	28	8.74	7.08	248,480	201,270	0.87
F	15	First ratoons	13	6.82	5.52	175,800	142,390	0.95
S	7	Fourth ratoons	16	6.82	5.52	181,350	146,890	0.98
T	7	Fourth ratoons	16	6.95	5.63	162,600	131,710	0.86
U	7	Third ratoons	16	7.41	6.00	179,000	145,010	0.89
V	7	Third ratoons	15	7.41	6.00	179,000	130,340	0.80
Average				7.36	6.01	181,900	145,250	0.86

From the above we see that the acre inches applied per acre when measured at supply meter varied from 8.74 inches to 6.82 inches with an average of 7.36; when measured at the watercourse these figures become 7.08 inches maximum, 5.52 inches minimum and 6.01 inches average. The gallons of water per man day measured at the supply meter varied from 147,000 to 248,000, averaging 181,900 gallons.

The area irrigated per man day was 0.86 acre. We feel that this is somewhat low. Irrigation at Waipio is on the day basis, as we have not found it practical to give long term contracts. We are now working on a plan to have the irrigation done by the short, individual contract system.

Age of Cane and Amount of Water Applied per Acre

As the cane becomes older, trash accumulates in the bottom of the lines and cane stalks tend to obstruct the lines and watercourses, slowing up the water and causing more seepage. This increases the amount of water used per irrigation.

The figures at Waipio were as follows:

16 months cane = 8.06 acre inches per irrigation;

7 months cane = 7.15 acre inches per irrigation.

In other measurements not reported here, we applied about 3 acre inches in plant cane 3 months old.

Increasing the Head, Lessened Amount of Water Applied per Acre

In making this test the same irrigator was used. The head of water given him was varied with the watercourse. The irrigation was done by irrigator No. 79, one of our best men. The results show as follows:

Watercourse	Gallons Water Per Man Day	Acres Per Man Day	Acre Inches Per Acre at Watercourse	Gallons Per Acre
8	149,200	.954	5.76	156,400
10	155,300	1.222	4.68	127,100

By speeding up the work in this case we were able to reduce the acre inches applied from 5.76 to 4.68 inches per acre. This represents a saving of 29,300 gallons of water per acre, or 12½ per cent. At $20.00 a million gallons this amounts to 59 cents per acre per irrigation. In conducting this test every effort was made to keep all conditions the same except the change of head of the water. The same irrigator as before noted, worked in watercourses near to each other on the same level ditch. The two line "come-back" system was used in irrigating, and the water was stopped as soon as it reached the end of the second line. With this in mind we feel safe in stating that difference in water used per acre, 29,300 gallons, represents extra seepage. This is a direct loss for Waipio conditions, as a three-inch irrigation is about all the water Waipio soils will hold to a depth of six feet under normal moisture conditions. These results point to the importance of using as large a head of water as the condition of the soil will allow. But one must bear in mind that merely increasing the head is not all that is necessary. All the good of the increased head may be lost if the irrigation is allowed to fill the line too much. We are inclined to believe that there is nothing to gain, and much to lose under most conditions, in allowing the water to run into an ordinary length line longer than it takes to run from one end to the other.

We are of the belief that in the majority of cases irrigating and weeding by the same man leads to a waste of water and is a great deal more expensive than we realize. Separate weeding would lead to economy of water.

Variations Among Individual Irrigators

We found a rather wide variation in the areas covered and the amounts of water used by different irrigators and by the same irrigators from day to day. The average work of the different irrigators in the various fields irrigated during this test is summarized:

Irrigator	Acre Inches* Per Acre	Acres Per Man Day	Gallons Per Man Day
Bango 22	5.40	0.88	129,030
3	5.46	0.92	136,400
79	5.58	0.92	139,400
64	5.66	0.91	139,860
61	5.68	0.85	131,100
7	5.72	0.97	150,660
34	6.43	0.84	146,600
13	6.48	0.86	151,330
17	6.48	0.87	153,100
98	6.81	0.79	146,100
83	6.90	0.66	123,660
53	7.03	0.77	147,000
24	7.10	0.90	173,510
Average		.86	

The first six men in the above list did better than the others. Illustrating, let us take irrigators Nos. 22 and 24. They irrigated approximately the same area per day, but No. 24 used 44,500 gallons more water per day. At $20.00 per million this amounts to 89 cents a day. For Waipio conditions we feel certain that any irrigation of more than 5½ inches is of no benefit. No. 24 is not irrigating any more.

The Philippine Mole-Cricket Wasp (*Larra Luzonensis*) in Hawaii

By Francis X. Williams

The mole cricket is almost wholly a subterranean insect. Its small, protuberant beady eyes seem to suggest that it is a creature of the darkness. Unlike the ordinary field cricket with its more exposed manner of living and depending in great measure upon agility for safety, it has little use for leaping powers within the narrow confines of its burrow and has developed instead remarkably large and strong hands and a long cylindrical body that serve its purpose admirably.

At certain times the mole cricket will migrate on top of the ground, or the long-winged form takes flight and is frequently attracted to light. It is a very extensive burrower, usually quitting its more secure and deeper day-tunnel during the night to make the well-known superficial burrows that appear as low cracked ridges along the surface of the ground. Of long life and more or less omnivorous in habit this insect is often guilty of serious depredations on crops, the "Changa" or West Indian mole cricket (*Scapteriscus vicinus*) being particularly notorious in this respect. On the island of Oahu, Hawaiian Islands, the immigrant mole cricket *Gryllotalpa africana* occasionally does considerable injury in cane fields

* Water measured at watercourse.

by eating the eyes, shoots, roots, and even the ends of the "seeds" themselves; in addition, it burrows into irrigation ditches thereby causing leakage. (See Swezey, *Planters' Record,* XXVII, pp. 38 and 39, 1923.)

Mole crickets, of which there are several genera and numerous species, generally frequent moist places and are very expert surface swimmers. With such profound and secretive habits, one would not expect them to have many insect parasites, which indeed seems to be the case, a single genus of wasps, *Larra,* appearing to figure alone in this role. Nowhere are these wasps represented by many kinds, and of the ten or more species studied from a standpoint of life history, each wasp seems addicted to a particular species of mole cricket. Thus the Brazilian *Larra americana* preys upon *Scapteriscus didactylus,* the Australian *Larra femorata* and *Larra scelesta* upon *Gryllotalpa coarctata* and *Gryllotalpa nitidula* respectively, while in the Philippines, the large, forest-loving *Larra carbonaria* attacks *Gryllotalpa hirsuta* of similar habitat, with a new species of *Larra,* and *Larra luzonensis* having the widespread *Gryllotalpa africana* as their host. These wasps explore the mole cricket tunnels, often penetrating very moist soil, drive the occupant to the surface and there do battle with it, nimbly springing upon its back and administering stings in the soft underside of the thorax and head; in this way the cricket, which may be young or full-grown, is paralyzed for a length of time sufficient for the wasp to glue her egg firmly under the thorax. Soon the victim revives and hastily burrows in the ground to lead an active life until it succumbs to the developing wasp grub, which often consumes it in its entirety and spins a hard oval cocoon. The total life cycle for these insects in the tropics seems usually between 6 and 9 weeks duration.

While at Los Baños in July, 1917, the writer made a few observations on the life history of *Larra luzonensis* and succeeded in rearing a specimen from egg to maturity, the cycle occupying forty-two days. On his second trip to the Philippines, more *Larra luzonensis* were secured and a very small shipment of it sent to Honolulu in August, 1921. But 4 wasps, apparently all females, issued from the lot and were liberated in Manoa Valley, on September 19. In December of the same year another small lot of *Larra luzonensis,* and a slightly larger one of a rarer *Larra* with a red abdomen that also preys on the mole cricket we have in the Hawaiian Islands, was sent to Honolulu. From this lot resulted, again, 4 females of *Larra luzonensis* and from the 13 cocoons of the red kind, 9 females and 2 males issued, of which 8 females were liberated in Manoa Valley. No wasps became established from these two shipments.

In July, 1924, I succeeded in bringing from Para, Brazil, a lot of about 55 cocoons of two species of *Larra, Larra americana* and a smaller species, both having a black and red body, that preyed upon two species of *Scapteriscus.* Upwards of two dozen wasps issued, mainly in Honolulu, a few perishing during the voyage thereto. *Larra americana* prevailed in numbers. As their prey differed from *Gryllotalpa* not much hope was entertained of these wasps becoming established on Oahu; they did, after considerable coaxing, parasitize our mole cricket, but only a few mated females could be obtained, and of these 3 mated pairs of *Larra americana* and 4 mated females and 1 male of the second species

were liberated in a wet sugar cane field infested with mole crickets, on Kahuku plantation. No success appears to have attended these liberations.

Larra luzonensis, except in certain localities, seems quite rare in the Philippines, but C. E. Pemberton, associate entomologist of this Station, who went to the Philippines in 1925, hit upon the happy expedient of spraying corn plants at Los Baños with a saturated sugar solution and thereby attracted the desired insect in sufficient quantity to breed enough for three large shipments to Honolulu. These were received June 10, June 24, and July 8, 1925. From these lots, totalling 577 parasitized mole crickets, 184 wasps are known to have been produced; in addition 79 cocoons were buried on two sugar plantations. The insect was liberated as follows:

Ewa Plantation Company—Field 5, mauka end. Seventy-two adults, from June 20 to July 20.

Waialua Agricultural Company—Field Mill 9. Forty-nine cocoons buried June 26; 44 adults, July 13.

Kahuku Plantation Company—Field 2B, 30 cocoons buried July 10.

Manoa Substation—68 adults from July 7 to July 29.

This *Larra* has found conditions to its liking in these Islands, for it has become very thoroughly established. On September 3, 1926, we found it numerous, for this type of insect, on Waialua Agricultural Company, occurring in Mill Fields 6 and 9, and at 2D Kawaihapai; on September 7, it was recovered from Field 5, Ewa Plantation Company; it has not yet been seen at Kahuku; in Honolulu the first specimen was captured on a screened window of one of the beach hotels on October 2; on October 25, a parasitized mole cricket was taken at about 1,700 feet on the peak of Tantalus and subsequently wasps were abundant there; November 9, fifteen or twenty specimens were found at Ewa in Field 5, and one specimen was taken in Field 13B, there. Males may be seen in abundance feeding on certain honey-dewed bushes at the head of Manoa Valley.

This useful wasp resembles somewhat the Philippine field-cricket wasp, an insect about the same size but generally grey-black in color, lacking the red of the middle legs and possessed of greater activity. *Larra luzonensis* may be recognized by its polished black abdomen, the red on the middle pair of legs and by the manner in which it hunts its prey; it explores mole-cricket-burrows, now and then disappearing in one of them, and the often punctured condition of these burrows indicates the abundance of the wasp. It is to be looked for on the plantations along the moist, more exposed open ditch banks. Already it is far more numerous here than at Los Baños, whence it comes. Thanks to a scarcity of natural enemies here, it should be expected to greatly lessen the numbers of mole crickets in our fields. Being so active a wasp, it must soon reach the island of Kauai, the only other island of the archipelago where its natural prey is known to occur.

A South American Ground Beetle as a Wireworm Enemy

By Francis X. Williams

The ground beetles or Carabidae constitute one of the largest and most important families of the Order Coleoptera, and as their common name implies, occur on or near the ground, remaining in concealment during the day and coming out at night to prey upon weaker insects and other invertebrates. Many of the commoner forms are black in color and are protected from their enemies by their swiftness of movement, secretive habits, or by a malodorous quality.

There are numerous exceptions to the general habits among these insects, particularly in tropical regions, for we know of many "ground" beetles that live in trees, a fact particularly true of the Carabidae of the Hawaiian Islands. And in the New England states, the large, brilliantly metallic *Calosoma sycophanta,* an introduction from Europe, may be very conspicuous as it scales the trunks of forest trees in broad daylight in search of its large and succulent prey, the caterpillar of the Gypsy moth. Other and native species of *Calosoma* are often seen hurrying over the ground in the daytime.

The great majority of Carabidae are mainly predaceous and play an important part in suppressing injurious insects, destroying them particularly in the larval stages; certain ground beetles, however, enjoy a mixed diet, feeding both upon plant and animal substances and thus such genera as *Harpalus, Anisodactylus* and *Amara,* may be quite injurious as seed eaters.

The ground beetle figured in this article is one of the Scaritini, a tribe whose members are particularly terrestrial and whose early stages are passed underground. It was rather abundant in the city of Belem, Para, Brazil, where both larvae and adults were dug out of the sandy soil. No eggs were found. Presumably these are laid underground, hatching out as slender active larvae that much resemble wireworms, though generally more elongate and possessed of a truculent disposition. When full-grown (Fig. 1) the larva is about an inch long with the head and thorax of darker color and harder than the rest of the body, which is pale yellow with the tail end forked. The legs are strongly developed for rapid progress through the soil, being much thickened and provided with stiff spines. At this stage it is of considerably greater length though far slenderer than either pupa or adult. The pupa particularly, is very short inasmuch as the head is bent down upon the breast (Fig. 2), while in the adult (Fig. 3) it is extended as usual. The pupa is somewhat less than half an inch long and has the back provided with some erect hairs that probably serve to keep it off the moist soil as it lies in its pupal chamber. The beetle, which measures about ⅔ inch long, is at first soft and pale but its integument soon hardens and the color becomes a polished black. It is quite incapable of flight, having no wings under the fused elytra or wing cases. The tibia of the forelegs is strongly broadened and armed with heavy spines and forms an excellent digging apparatus. Its well developed mandibles

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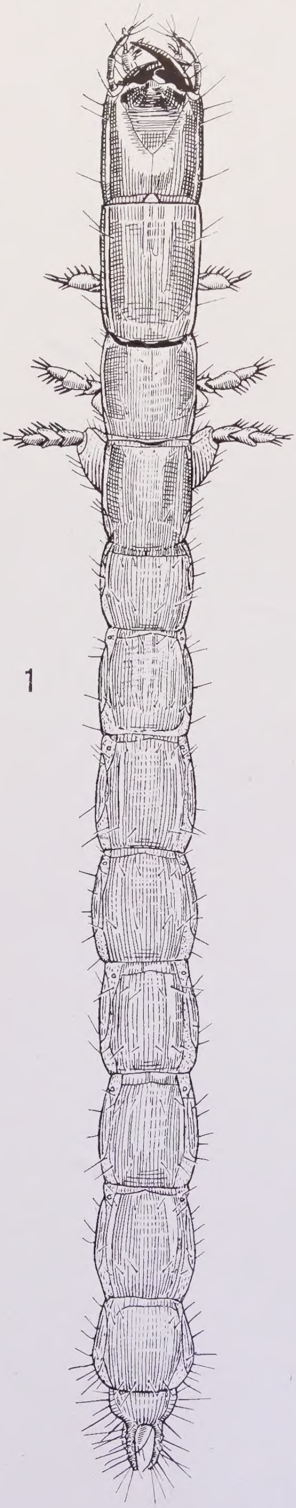

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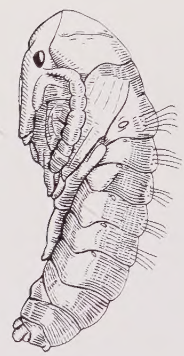

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indicate a predaceous habit. The majority of specimens were found at the bottom of rather deep and nicely cylindrical burrows.

By dint of much digging during May and June of 1924, in a garden in Belem, a small lot of larvae and adult Scaritini were secured, nearly all of which survived (without food) the four weeks' trip from Brazil to Hawaii, where they—14 adults and 11 larvae—as well as a single specimen of a larger species, were liberated on the Honokaa Sugar Company plantation. They have probably not become established, in view of the small size of the shipment, the comparative paucity of animal food available in the soil, and the rather long developmental stages of the beetle. The adults in some cases readily seized hold of larvae or pupae of *Monocrepidius* wireworms that were offered them, and the grubs are fully able to overcome softer insects, as white grubs.

Pre-Harvest Sampling for Cane Ripening*

By W. P. Alexander

Head of Department of Agricultural Control and Research, Ewa Plantation Company

Which field shall be harvested next?

This is a question which has to be answered by the management of a plantation many times during the season. If every field could be harvested when it was ripe, the production on all plantations would be greatly increased. This is asking the impossible, for, due to mill capacity and labor supply, the grinding season lasts from six to eight months. Also, fields to be planted and to be short ratoons are harvested early. There must be a compromise, and the management that is able to schedule the harvest of the fields with some definite knowledge of the *stage of maturity* will be in a position to increase sugar yields. Appearance of the cane field is often deceptive as regards its ripeness.

One then naturally asks: Is it not possible to cut samples in a field of cane before harvest and from an analysis of the juice determine its ripeness? It would be the logical thing to do, and, offhand, seems a very simple method of securing the desired information. I have been unable to find out just how many plantations attempt to obtain such samples regularly throughout the grinding season and the technic involved. I hope discussion at this meeting will bring out this point. The Ewa Plantation Company inaugurated a program of *systematic* pre-harvest juice sampling in September, 1924, and a year later the Oahu Sugar Company started using the Waipio test mill for a similar purpose. Both plantations had previously taken samples on special occasions but there had not been a definite plan for the entire crop. I append a letter from H. W. Robbins, chemist at Oahu Sugar Company, analyzing his results for the 1926 crop. His methods of sam-

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* Presented at the fifth annual meeting of Association of Hawaiian Sugar Technologists October, 1926.

pling are essentially the same as those used at Ewa and the cane is also ground in a "Cuba A" mill manufactured by the Squire Manufacturing Company. Data therefore should be comparative.

Cuba "A" mill used to grind pre-harvest juice samples

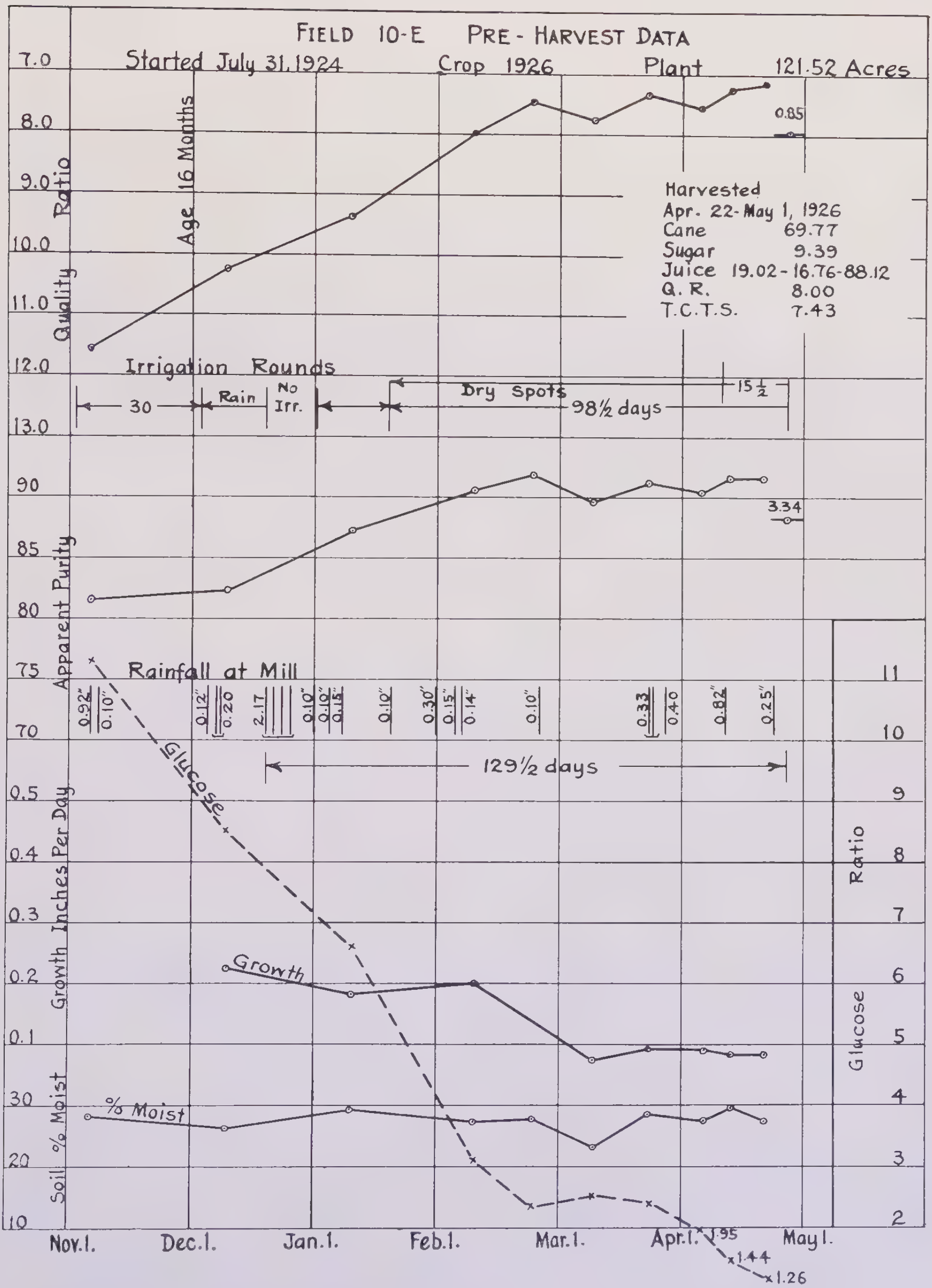
The following brief remarks will treat of the procedure followed at Ewa Plantation Company and the conclusions that can be drawn to date:

Three methods of sampling have been tried, namely: (1) Carload lots from edge of field crushed at mill; (2) Five stalk samples ground in test mill (see photo); (3) Java system—five stalk samples divided into three equal portions of top, middle, and bottom and the juice from each section analyzed separately.

The first gave very erroneous results, as the cane invariably seemed to have better juice on the outside of the field. The third gave very interesting information, but was of no more practical value than the second, which will be described in detail. Areas are selected in a field which appears to represent average conditions. One site is chosen for every 20 acres or more, depending on soil variation. It is situated at least 100 feet from the edge of the field and at least 50 feet from the nearest ditch and also 10 feet from a watercourse. Five stalks are cut from a stool or stools in consecutive order along the same cane line. They are topped at the base of the fifth leaf. Care must be taken not to break and lose the stalks which may be as long as 15 to 20 feet entangled among other stalks in a veritable jungle. At the same time a boring is made to a 2-foot depth and a soil sample is obtained from which a moisture determination is secured. Growth measurements are made on five adjacent stalks of cane. The above operation, including packing out the sample and moving to a new location, consumes on an average 40 minutes. Two men usually work together, and they must be conscientious and reliable if the work is done properly. Samples start 8 to 6 months previous to harvesting and are taken at periods of from 1 to 4 weeks, the interval decreasing as harvesting approaches.

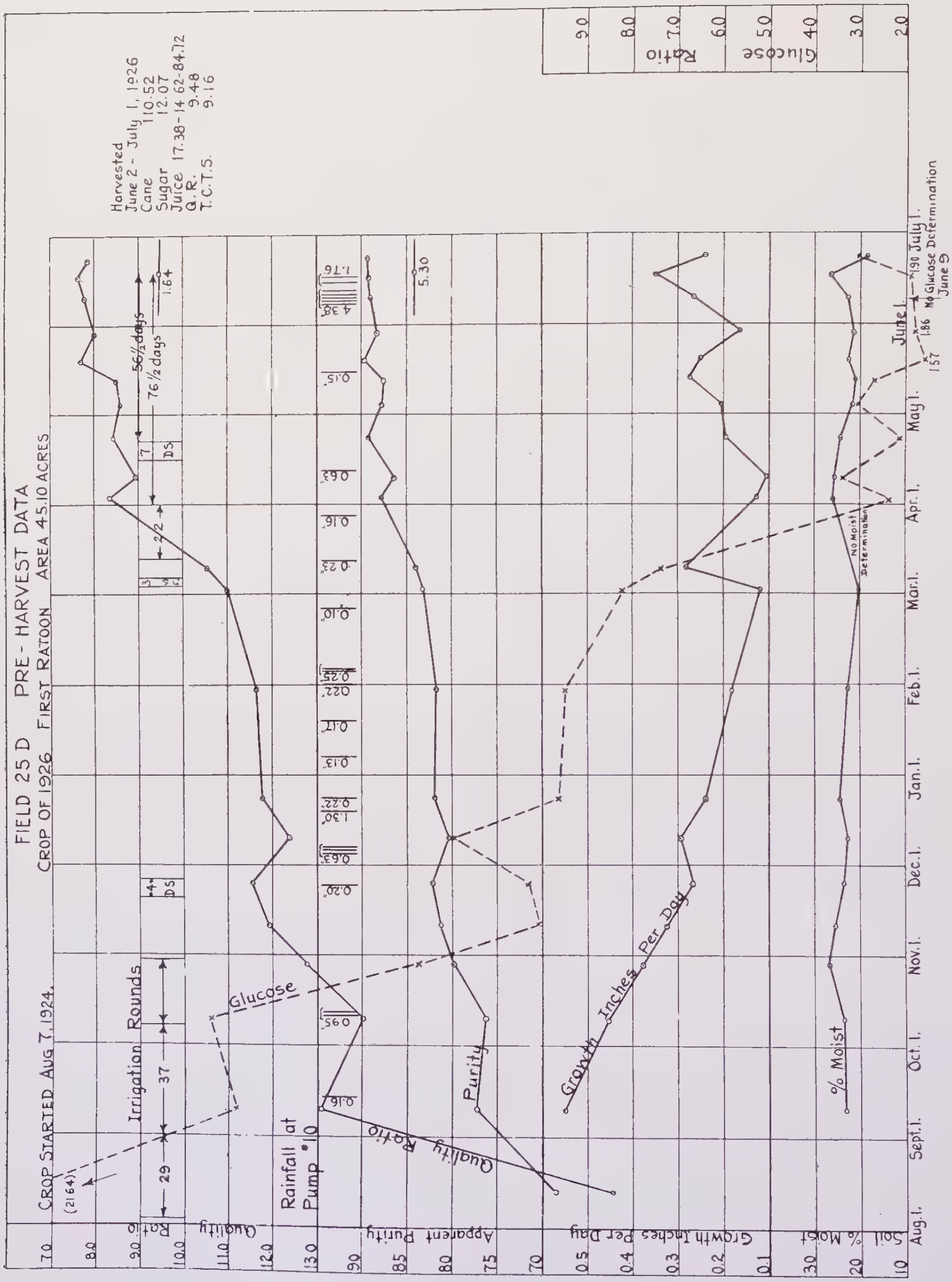
The cane is weighed* and ground in a motor-driven "Cuba A" mill having polarization extraction of 60 to 65 per cent. Analysis of juice shows Brix, polarization, purity, quality ratio, glucose, and glucose-polarization ratio.

Records are kept on a visible card index and also graphed as shown in Graphs 1 and 2.



Graph 1

* Also measured at Oahu Sugar Company.



Graph 2

We are trying to sample a non-uniform material—a field of maturing cane. Just how great this variation within a single field is from a group of 5 stalks to another group of 5 stalks was emphasized when a series of 60 samples was taken in sets of ten. The first ten samples had an average quality ratio of 7.49 while the individual five stalk samples taken consecutively at the same time gave quality

ratios of 7.30, 8.20, 7.33, 7.16, 7.11, 7.42, 6.50, 7.32, 9.80 and 7.26. (It would be my guess that the next to the last sample contained a sucker.)

The second averaged 7.12 quality ratio and individually showed: 7.37, 7.11, 7.13, 7.18, 7.18, 7.80, 6.74, 7.06, 6.82 and 6.93.

The third averaged 7.84 quality ratio and individually showed: 8.17, 7.78, 7.18, 8.13, 7.73, 7.68, 7.18, 7.83, 8.52 and 8.40.

The fourth averaged 7.94 quality ratio and individually showed: 7.76, 7.66, 7.17, 7.45, 8.64, 7.07, 8.17, 7.94, 8.63 and 9.52.

The fifth averaged 7.07 quality ratio and individually showed: 6.59, 6.86, 6.94, 7.58, 7.87, 7.16, 7.47, 7.08, 6.76 and 6.65.

The sixth averaged 7.25 quality ratio and individually showed: 6.56, 6.65, 8.11, 7.03, 7.14, 6.84, 7.12, 7.58, 7.51 and 8.38.

A study of the actual samples of crusher juice from individual fields of the 1926 crop shows that the quality ratio had a mean deviation of ± 0.47. In other words, while the average quality ratio might be 8.0 we could expect daily samples to range from 7.5 to 8.5. With these fluctuations within a field of cane, due to the many uncontrollable factors of environment and growth, one cannot expect five stalks of cane chosen from 20 acres of a field to pre-determine the exact status of the entire portion of the field. Theoretically, the greater the number of samples one takes the closer one will approximate the true condition of any given field, but a limit is reached due to the added cost of such intensive sampling. If one could find a sample location or locations approximating field average, the data would be satisfactory. Selections of such average sites must be based upon past experience. A trial is being given this method of sampling.

With such great divergency of sucrose content within the field it would be anticipated that the pre-harvest juice samples would not be comparable to the crusher juice. The average differences between the crusher juice of the field and the juice samples from the test mill, just previous to harvest, are given with the mean deviation from the average:

	Average Difference	Mean Deviation
Brix	+0.4	$\mp$0.7
Polarization	+1.1	$\mp$0.9
Purity	+4.0	$\mp$1.5
Quality Ratio	+0.8	$\mp$0.5

Some of this increase for the test mill, of course, is accounted for by having clean, unburnt cane milled immediately after cutting. The difference, however, is not consistent enough so that a correction factor can be applied. To illustrate, a typical comparison is shown:

	Typical Field Crusher Sample	Average Range of Pre Harvest Samples Minimum	Average	Maximum
Brix	18.5	18.2	18.9	19.6
Polarization	16.0	16.2	17.1	18.0
Purity	86.5	89.0	90.5	92.0
Quality Ratio	8.5	8.2	7.7	7.2

These, therefore, seem to be the average limits within which pre-harvest juice samples can be made for one particular local condition.

The work done in sampling cane for ripeness during the 1925 and 1926 crops at Ewa should be considered experimental, and was used for two purposes, viz: (1) Actually furnishing the management with data as to fields which had the highest sucrose content and those which were in the various stages of maturity, and (2) in studying the cane ripening process from a theoretical standpoint.

The present status of the project may be stated as follows: It is doubtful if a few samples can be secured that will be a representative index of the field as a whole or even portions. However, it is possible to obtain from the samples the general trend of the ripening process over a period of months. These typical changes in the formation of sucrose are shown in Graphs 1 and 2 and are of practical value in bringing the cane to its highest peak of sucrose.

By a liberal interpretation of such charts, one was able to better direct the project of sucrose improvement, i. e.:

(1) One was able to follow the ripening process previous to suspension of irrigation and better control the amount of water.

(2) One had a better basis upon which to decide from a small group of fields scheduled for a certain month, which particular one was mature.

(3) One knew in what stage of ripeness the fields were at any particular time. Whenever a field showed a tendency to go back, one usually was able to detect the lowering of purity before the damage had become acute and remedy the situation by harvesting the cane.

(4) In general the preliminary sampling of the fields furnished information that indicated the best way of ripening a field and when to harvest to secure the highest sucrose content.

Mr. Robbin's letter, giving his results of analysis for the 1926 crop, follows:

The tables enclosed show the results of our field sampling during the past crop.

In Table 1 a comparison is given between the average of the crusher juice from thirty-one fields and the last field sample taken from the same fields previous to harvesting.

The ratio between the small Waipio mill and our crusher juice had previously been determined by the H. S. P. A. on the scale of harvesting at Waipio. The ratio resulting from the averages of the thirty-one fields shown, is somewhat higher and may be due to evaporation in the cane harvested. While the sucrose extracted by the crusher approximates that extracted by the Waipio mill the glucose is much higher. The Waipio mill juice represents cane uniformly topped and ground immediately after cutting while the crusher juice represents all the cane, including the suckers, and was subject to the unavoidable delay in grinding, when harvesting over a large area.

In connection with this work we have been trying to find a method for using the ratio of the polarization to the glucose, in crusher juice, as a guide to the ripeness of the cane. It was thought that a high per cent of solids not sugars, would give a low purity to a juice from cane that might be ripe. To start with, we assumed that when the polarization was 35.5 times the glucose the cane was ripe. That ratio was then taken as a standard of ripeness equal to 100. This figure per cent standard of ripeness fluctuates widely with small changes in the polarization and glucose, but does not indicate when the cane is at the ripest stage.

In Table 2 the fields are given in the order of their purities. There was not a great deal of variation in the non-sugars, and consequently the standard of ripeness followed the purity in general. The three fields planted to D 1135 were all high in non-sugars. Two of those fields, 4B and 57D, were harvested at the beginning of the crop and were low in purity and per cent standard ripeness. The other field, 43, was harvested during the

middle of the crop and stood seventh in the scale of ripeness and twenty-eighth in purity, due to low glucose and high non-sugars.

The following letter was received on December 31, 1926 (two months after presentation of the above paper), and gives in more detail the work of the Oahu Sugar Company:

Cane ripening studies were started on the Oahu Sugar Company, in September, 1925. At this time, the immediate object in view was to try out systematic pre-harvest juice sampling as against carload lots from the edges of fields. The first year of this work was devoted to furnishing the management with data showing the relative ripeness of fields from time to time. We were also studying the cane ripening processes in their relationship to cultural practices and irrigation.

The ultimate end in view of this work is to control the ripening of our fields, as far as possible, through the regulation of our cultural practices, chief of which is irrigation, in an endeavor to reach a maximum ripeness of the fields. In addition, the harvesting schedule may be rearranged within certain limits from time to time depending upon the maturity and ripeness of the fields.

The general procedure for pre-harvest sampling is briefly as follows:

A plot is selected in each 20-25 acres of cane so located that the average of all plots will be representative of the field as a whole. Each plot is located between 75 to 100 feet from the edges of the field or from ditches. One stalk is cut from each of five lines in the plot no less than six feet from the watercourse. The stalks are cut flush with the bottom of the furrow and topped at the base of the eighth leaf. The next set of samples is taken, at a later date, just beyond the last sample.

The stalks are carefully dragged out of the field and are measured and bundled by plots. Then they are taken to the mill, weighed by plots and crushed; the juice from each plot is analyzed separately. The cane is ground in a "Cuba A" mill. The following data are recorded:

Date	No. of Stalks	Length of Stalks Total	Length of Stalks Average	Weight of Stalks Total	Weight of Stalks Average	Weight per Foot of Cane

Brix	Pol.	Purity	Quality Ratio	Glucose	Pol. Glucose	Remarks

Correction factors are used to translate the "Cuba A" mill analyses in terms of the commercial mill.

Samples at monthly intervals are taken from four to six months prior to harvesting a field; the interval is decreased as harvesting approaches.

In addition to the above method, the Java system was tried for a while, but was abandoned for the reason that it did not give results commensurate with the tremendous amount of detail work. It gave us, however, very interesting data.

Carload samples from the edges of fields were not satisfactory in that they were not a true representation of the field and showed the relative ripeness of only a small part of the field.

Correct field sampling is an important problem in the study of cane ripening. There is a tremendous amount of variation between stalks in a field of cane because of stalks in various stages of maturity, rotten stalks, rat-eaten and borer-eaten stalks, tasseled stalks, etc. The question is what kind of stalks shall we take? What per cent of the whole does each kind of stalk represent? The problem of field sampling for studies of cane ripening processes would be solved if we knew the correct answer to these questions.

Variation in samples means variation in results so that the data must be interpreted liberally. We must also make allowances for a certain number of discrepencies entering into the work as well as the human element.

To sum up the work, it might be said that up to date, pre-harvest samples have furnished data to show the trend of field ripening from which we have been able to change the harvesting schedule to a certain extent with advantage. This applies to groups of fields only. The layout of a plantation as influenced by contour and also the method of harvesting have quite a distinct bearing on the subject.

The studies of cane ripening processes are being continued and amplified.

TABLE 1

Comparison Between Waipio Mill Juice and Crusher Juice for Thirty-one Fields—Crop of 1926

	Brix	Pol.	Purity	Glucose	Solids Not Sugars	Pol. Glucose	Per Cent Standard Ripeness	Solids Per 100 Brix: Pol. or Purity	Solids Per 100 Brix: Glucose	Solids Per 100 Brix: Non-Sugars
Crusher Juice	19.21	16.89	87.93	.80	1.52	21.1	59.5	87.93	4.16	7.91
Waipio Juice	19.04	17.38	91.28	.49	1.17	35.5	100.0	91.28	2.57	6.14
Crusher Waipio H. S. P. A.*	98.0	92.5	....	....	...	...	...	....	...	...
Crusher Waipio O. S. Co.†	100.89	97.18	....	163.3	...	...	...	....	...	...
Crusher Juice by H. S. P. A. Ratio	18.66	16.08	86.2	....	...	...	...	....	...	...

* The H. S. P. A. ratio between the Waipio juice and crusher juice was established by taking samples from cars of loaded cane that was ground soon after sampling.

† The Oahu Sugar Company ratio is a comparison of samples from the fields ground in Waipio mill, with the average crusher juice of the harvested fields.

TABLE 2

Cane Ripening Data—Crop of 1926

	Crusher Juice					Cane	
			Solids % Brix				
Field	% Standard Ripeness	Brix	Polar. or Purity	Glucose	Non-Sugars	% Pol'n	Tons Per T. 96°
45-A	77.1	20.01	90.2	3.3	6.5	15.70	6.71
45-B	81.5	19.63	89.9	3.1	7.0	15.43	6.83
46-B	76.1	18.93	89.9	3.3	6.8	14.66	7.11
39	60.5	18.76	89.3	4.2	6.5	14.68	7.12
22	75.2	19.43	89.3	3.4	7.3	15.16	7.04
23	82.1	19.98	89.0	3.1	7.9	15.34	6.84
48	67.2	20.10	89.0	3.7	7.3	15.35	6.96
24	82.0	20.30	88.9	3.1	8.0	15.66	6.81
36	71.9	20.70	88.8	3.5	7.7	15.71	6.74
37-A	80.0	21.41	88.8	3.1	8.1	16.42	6.51
35-A	65.7	20.01	88.7	3.8	7.5	15.42	6.91
15	68.6	19.24	88.6	3.6	7.8	14.82	7.08
44	61.3	19.65	88.6	4.1	7.3	15.12	7.07
16	65.1	19.82	88.6	3.8	7.6	15.13	7.06
18	67.8	20.11	88.5	3.7	7.8	15.26	7.01
37-B	57.2	18.01	88.5	4.3	7.2	13.71	7.74
4-A	72.8	20.19	88.4	3.4	8.2	15.09	7.06
47	53.1	18.58	88.2	4.7	7.1	14.18	7.43
13	63.4	20.90	88.2	3.9	7.9	15.73	6.83
27-A	69.3	20.10	88.1	3.6	8.3	15.28	7.04
21	54.9	19.49	88.0	4.5	7.5	14.81	7.25
46-A	49.6	19.44	87.9	5.0	7.1	14.80	7.30
25	57.3	18.98	87.9	4.3	7.8	14.27	7.46
49	48.2	17.93	87.8	5.1	7.1	13.61	7.77
50	44.7	17.28	87.3	5.5	7.2	13.02	8.10
57-B	47.0	18.15	87.3	5.2	7.5	13.65	7.85
12	59.3	19.77	87.3	4.2	8.5	14.79	7.22
43	72.7	19.28	87.2	3.4	9.4	14.67	7.38
17-A	45.27	19.01	87.1	5.4	7.5	12.14	7.45
9-B	53.6	19.91	87.0	4.6	8.4	14.72	7.34
27-B	57.8	19.57	87.0	4.2	8.8	14.61	7.43
14 E & F	50.4	17.93	86.8	4.8	8.4	13.46	7.97
5	61.7	19.43	86.8	4.0	9.2	14.71	7.39
4-C	56.4	20.15	86.3	4.3	9.4	14.82	7.38
35-B	43.7	17.78	85.6	5.5	8.9	13.16	8.25
14-D	40.0	18.16	85.4	6.2	8.4	13.89	7.89
59	48.3	18.50	85.2	5.0	9.8	13.74	8.04
14-A	40.5	18.60	84.9	5.9	9.2	13.89	7.89
34-A	44.0	17.60	84.3	5.4	10.3	12.76	8.77
33	47.1	17.69	84.2	5.0	10.8	12.79	8.54
34-B	43.7	17.55	84.0	5.4	10.6	12.61	8.82
4-B	37.7	17.59	82.9	6.2	10.9	12.54	8.90
57-D	34.5	17.05	82.7	6.7	10.6	12.18	9.29

Factory Test on Alkaline and Neutral Clarification

By W. L. McCleery

The following test was run at Ewa factory during the latter part of the 1926 grinding season. The object was to amplify our present data showing comparisons on a factory scale between "alkaline" and "neutral" clarification. By alkaline clarification is meant the method now in quite general use wherein the hot limed juice is held between 8.0 and 8.3 pH, at which point laboratory work at this Station has indicated the maximum increase of purity is obtained. Neutral clarification refers to the practice followed until a few years ago, in which the clarified juice and syrup were about neutral to litmus. It is recalled that the investigation of clarification was taken up as a major project by the sugar technology department of the Station in 1921. Early in 1922, Mr. Walker, then factory superintendent of the Pioneer Mill Company, began using the information by that time available, changing his method of operation to practically that now in general use. His first few weeks of experimental run showed an increased purity between mixed juice and syrup of somewhat over 1.2, or about double their usual figure. Since then alkaline clarification has, with the exception of a very few factories, become general throughout the Islands.

This experiment was arranged so that the higher liming was to be carried out during the day and the moderate liming at night. The day reaction of the cold limed juice was to be held between 8.6 and 8.8 pH, corresponding to approximately 8.3 pH on the juice leaving the heaters, and giving a clarified juice of about 7.5 pH with the syrup slightly lower. Factories grinding cane with low phosphoric acid content would need to lime to only 8.4 or 8.5 pH on cold juice to obtain these hot juice and clarified figures. The reaction at night was to be from 7.8 to 8.0 on cold juice with the clarified juice in the neighborhood of 7.0 pH.

The comparative data to be obtained besides pH determinations included difference in syrup purity, as well as difference in purity increase from mixed juice to syrup; also turbidity by the Kopke turbidimeter and syrup filtration rates by the Elliott apparatus and by the pressure filter of the Celite Products Company.

The test started July 29, 1926, and lasted nine days. The prescribed limits of liming were closely adhered to with the exception of one day and night during which time the above figures on cold juice were slightly exceeded. The pH determinations, purities and turbidity data are from laboratory records as determined in the regular routine. The Elliott filtrations were run by the writer and the pressure filtrations by Mr. Elsenbast, of the Celite Products Company. The averages given below are arithmetical including those of pH determinations.

The tabulations show that the cold juice average pH was 8.75 on the day and 8.06 at night, with the clarified juice 7.55 and 6.97 respectively. The drop in pH from cold limed juice to clarified was somewhat greater than found in some factories, but during this time the phosphoric acid in crusher juice was .043 to .059 per cent (.227 to .330 per cent Brix), all higher than the general

average, so that this drop can be considered normal. The pH drop from heated juice to clarified is not affected by the fluctuations of phosphoric acid present in raw juice. Therefore the pH of hot juice used as the basis of liming control is the means of obtaining the most even reaction on clarified juice and syrup.

The turbidity was markedly better on the day than on the night shift with the exception of the first day. The average was 3.83 against 3.08. The day figure was close to the expected for the above amount of phosphoric acid with the day shift pH values.

A higher syrup purity was obtained on each day shift than on the corresponding night shift, the average difference being 0.96. The purity increase from mixed juice to clarified averaged 0.88 higher on day than night. As there is a lag of close to three hours between the raw juice and syrup stages in the factory, it is likely that the purity and filtration rate differences given below represent only from 50 to 75 per cent of the actual. There was no allowance for this lag in time, because of the large amount of work being handled by the laboratory and for fear of confusion resulting in wrong compositing of the day and night samples.

The Elliott or vacuum filtration rate on syrup of 43.6 per cent for the day compared with 38.6 for the night, with pressure filtration rates of 112 and 97 respectively, show a difference in favor of the day with the Elliott test of 13 per cent and of 15 per cent for the pressure filter. It is noticed that at the end of the run the filtration rates were much lower than at the beginning, even though all factory conditions were kept as uniform as possible. Fluctuating rates over a wide range were found to be characteristic during the period of over seventy consecutive days this summer that these data were kept at this factory.

Conclusion

An improvement in purity between the two methods of liming of about 0.9

	DAY				NIGHT					
	Mixed Juice		Syrup	Inc'r	Mixed Juice		Syrup	Inc'r	Differences	
Date 1926	pH (Cold)	A. Purity	A. Purity	Purity	pH (Cold)	A. Purity	A. Purity	Purity	pH	Purity
7/29	8.63	82.4	85.02	2.62	8.25	82.3	84.93	2.63	.38	—0.01
7/30	8.37	80.9	84.66	3.76	8.16	81.7	84.20	2.50	.21	1.26
7/31	8.78	80.8	84.50	3.70	8.00	82.0	83.86	1.86	.78	1.84
8/2	9.05	81.8	83.90	2.10	8.75	81.9	82.70	0.80	.30	1.30
8/3	8.83	81.9	85.16	3.26	8.46	81.1	82.88	1.78	.37	1.48
8/4	8.83	81.7	83.89	2.19	7.90	80.5	82.83	2.33	.93	—0.14
8/5	8.78	80.7	84.28	3.58	7.88	80.7	83.31	2.61	.90	0.97
8/6	8.70	82.6	85.49	2.89	7.30	82.7	84.20	1.50	1.40	1.39
8/7	8.77	81.4	84.28	2.88	7.86	80.6	83.71	3.11	.91	—0.23
Average	8.75	81.58	84.58	3.00	8.06	81.50	83.62	2.12	.69	0.88

Date 1926	ph CLARIFIED Day	ph CLARIFIED Night	pH SYRUP Day	pH SYRUP Night	TURBIDITY CLARIFIED Day	TURBIDITY CLARIFIED Night
7/29	7.48	6.94	7.3	7.0	3.37	3.83
7/30	7.56	7.14	7.2	6.6	4.04	3.74
7/31	7.58	7.17	...	7.0	3.53	3.22
8/2	7.50	...	7.3	...	3.80	...
8/3	7.34	7.20	6.9	7.1	3.92	3.32
8/4	7.30	6.76	6.8	6.9	4.00	2.62
8/5	7.88	6.63	7.4	6.6	4.35	2.35
8/6	7.44	6.90	...	7.1	3.46	2.58
8/7	7.86	7.00	7.6	7.0	4.00	2.94
Average	7.55	6.97	7.22	6.92	3.83	3.08

Date 1926	SYRUP FILT. RATE VACC. FILTER Day	SYRUP FILT. RATE VACC. FILTER Night	F. R. Difference	SYRUP FILT. RATE PRESSURE FILTER Day	SYRUP FILT. RATE PRESSURE FILTER Night	F. R. Difference
7/29	63.9	52.4	—11.5	200	142	—58
7/30	46.3	58.2	+11.9	172	182	+10
7/31	48.3	45.9	— 2.4	130	116	—14
8/2	...	...	...	...	...	....
8/3	49.8	44.7	— 5.1	100	102	+02
8/4	35.9	31.1	— 4.8	63	68	+05
8/5	35.6	22.1	—13.5	72	28	—44
8/6	33.6	26.0	— 7.6	47	42	—05
8/7	35.0	28.6	— 6.4	...	...	....
Average	43.6	38.6	— 5.0	112	97	—15
	+13%			+15%		

represents an increased recovery by S. J. M. formula of 0.7 per cent, or 7 tons more sugar per 1000 tons production. The lower liming with 6.97 average pH of clarified juice represents some inversion or destruction of sucrose as shown by research work recently published by this department. The greater clearness of clarified juice and better filtration rates found are also of some importance, as they result in cleaner and somewhat better filtering sugars at the refinery, and these items are obtained incidental to the larger increase of purity.

In general these results confirm on a factory scale the indications found in previous experimental work and give comparative figures between what is considered the optimum method of liming and the method formerly in use.

The writer is especially indebted to Messrs. Orth, Bond and Nolan, of Ewa Plantation, and Mr. Elsenbast, of the Celite Products Company, for cooperation in carrying out this test.

Reports on Foreign Work in Entomology

By C. E. Pemberton

Menado, Celebes, September 30, 1926.

I have spent most of September away from Menado searching for parasites of *Rhabdocnemis* other than the one species I have already mentioned. I visited some of the small islands lying between Celebes and the Philippines, extending northeast from Celebes about 200 miles. In a way these islands are greatly isolated, since they are separated from the Philippines, Celebes and each other by sea-depths ranging from 3000 to 6500 feet. As they lie in a more or less direct line in the distribution of *Rhabdocnemis* between Celebes, the Moluccas and the Philippines, I had some hopes of finding something interesting and of value. I examined palms on the islands of Togoelandang, Siao, Sangir and Taland (Salibaboo or Tulour) and some sugar cane on Taland, but found no *Rhabdocnemis* at all. On all of the islands sugar palms, sago palms and sugar cane are scarce, which perhaps accounts for the absence of the beetle. Some of the islands are almost completely covered with coconuts.

On Sangir Island, I was fortunate in having opportunity to see a striking example of what can happen on an isolated island when an introduced insect pest gets away from its parasites and other natural enemies. A scale insect, *Aspidiotus destructor,* was first noticed by the natives on a few coconut trees in a village at the north end of the Island 16 months ago. It has spread from this spot in a solid belt and killed outright about 500 acres of mature coconut trees and continues to advance. As the copra industry is a large one on this Island and the only one, this destruction, if unchecked, will literally drive the native population from comparative wealth to extreme poverty. As I was the first entomologist to see this, the only white man on the Island greeted me most effusively. In the affected belt every square inch of leaf surface is positively plastered with scales. These scales were unparasitized. In Java, Malay and probably other parts of the Archipelago this scale is well controlled by several parasites. I have informed my friend Mr. Leefmans, the Dutch Government entomologist at Buitenzorg, of this situation, and he is now preparing to introduce parasites to the Island. I think this is a most remarkable instance where the intelligent use of insect parasites can save an industry from complete ruin.

Upon returning to Menado I went into the elevated interior, living for a week at a place called Tondano. This is on a lake, about 10 or 15 miles long, at an elevation of 2250 feet. There are a good many sago swamps bordering this lake. In these I found an abundance of another species of *Rhabdocnemis.* During 5 or 6 days of work I succeeded in examining a thousand or more each of larvae, pupae, adults and cocoons and many eggs. Of this total only 3 were parasitized by the large *Ichneumon* which I mentioned in my last letter. The *Leptid* fly *Chrysopilus* was abundant. *Histerids, Hydrophilids* and *Anthocorids* were present but not common. The most effective check, as near as I could determine,

was the white fungous disease, which I have already sent from Menado. I found many dead larvae, pupae and especially adults covered with this fungus. This and the *Leptid* are the principal factors of control.

It is of interest that the two other small *Calandrid* beetles in this sago also suffered a heavy mortality from this fungus, yet I find no other of the many insects present in the sago attacked by it. The *Leptid* has proven itself adaptable to a wide variety of conditions, for I have now taken it in association with borers at sea level in sago swamps, in open fields in banana on banana borer, in the dark forests on *Rhabdocnemis* in sugar palms, in sago swamps at 2250 feet elevation as well as in sugar-palms there also, and in Java it was present with *Rhabdocnemis* in sugar palms at Lembang at 4000 feet elevation.

The *Rhabdocnemis* species which I found in sago at Tondano on the lake, does not seem to be present in the sago swamps at sea level near Menado, and I found more of it in sugar palms at Tondano and other elevated places which I visited. The common species of *Rhabdocnemis,* so like *obscura,* which I find here about Menado in sago and sugar palms, is also present in sago and sugar palms in the elevated districts.

I visited several places besides Tondano, namely: Rambokken, Kakas, Ratahan, Tomohon and Rurukan. Sugar palms are present in limited quantity everywhere, with the one species of *Rhabdocnemis* present, but I failed to discover any parasites or predators different from those about Menado, and nowhere did I find any favorable indication of the large *Ichneumon* pupal parasite, which is very disappointing.

Occasionally I find an adult *Rhabdocnemis* or larva dead with the green muscardine fungus *Metarrhizium,* but it would appear to be of no value at all as compared with the white fungus.

I am forwarding with this letter some specimens of this other species of *Rhabdocnemis* which I found in sago at Tondano. Included in the package is a specimen of a *Xylocopid* bee, something like the species in Hawaii, which bores in holes, posts, etc. I reared several hundred parasites from the larva of this bee, which I found in a dead limb in Menado. The dead larva and some of the parasites are also included in the package. As the *Xylocopa* is rather an economic pest in Hawaii, according to the Mutual Telephone people, I am sending this for what value it may have. Probably if efforts were ever made to introduce *Xylocopa* parasites to Hawaii, it should be started in the Philippines, from which region transportation is quite short to Honolulu, as compared with the Dutch East Indies.

At Mr. Muir's suggestion I examined some termites in Java for internal nematode parasites. The examinations were not extensive and I found none. Keeping it in mind, however, I have taken time to make some examinations about Menado. So far I have examined 3 genera: *Cryptotermes, Nasutitermes* (*Eutermes*) and *Termes.* I found nema in the abdominal cavity of immature nymphs of *Termes* taken from one colony, but none in the head, and also nema on the surface of the body of workers and nymphs in another colony of *Termes.* The nema were never abundant and only found after much dissection. Both *Termes* colonies appeared to be rather small, however. I have examined a large number

of *Nasutitermes* but have not seen a single nematode on or in any. I find no *Coptotermes*.

I am especially interested in an ant which lives within the *Termes* colonies directly with the termites. When first opening the covered earthen runways and seeing many of these ants I took them for strange modified forms of soldiers, but soon saw my mistake. These ants store large numbers of seemingly dead but preserved termites in parts of the nest reserved for themselves. These are probably stored for food.

In view of the presence of nema in certain termite colonies here, and of this interesting ant, and of still some hope for finding some other control factor on *Rhabdocnemis,* not yet unearthed, I do not feel justified in leaving Menado yet. I am quite a novice on ants and termites, but will devote a little time to it before leaving, especially the nema. I doubt if we want more ants in Hawaii.

Your letter of July 24 has just been received. The information you transmit with it respecting bird introductions to Hawaii, I find very interesting. I am very glad to have a copy of the resolutions passed by the Hawaiian Entomological Society on the subject.

I know nothing about the Peking nightingale, and unfortunately Menado is so far removed from the centers of scientific work in the Malay Archipelago and the Orient that there is no one here from whom I could obtain any first-hand information. If I, by chance, have any opportunity to learn anything about it, I will immediately forward the information. I suggest the name of Mr. McGregor, of the Philippine Bureau of Science, as a very reliable man to correspond with on the subject.

MAKASSAR, CELEBES, October 22, 1926.

I am today sending by registered mail a package containing living nematodes, reared from termites, collected at Menado, Celebes. This is addressed to Mr. Ehrhorn.

There are 8 tubes, each containing dead termites and from a few to several hundred living nematodes which have developed in the termites. In some of the tubes I have placed soil (sterile). In others there is nothing but the dead termites, the living nematodes and Tyroglyphid mites (living) which are often inseparably associated with the termites and cannot be avoided in the shipping of the nematodes. There are also a few Parasitid mites.

There will be many delays in the mails before this finally reaches Honolulu, and it is doubtful if any reach there alive, but it is well worth the trial. If the tubes do not dry out, many of the nema will probably still be alive.

Upon arrival I suggest that the contents of the vials be moistened, without removal, and living termites, especially *Coptotermes,* be inserted and left for 10 or 12 days, to permit development and multiplication of any nema that may be present.

I found that corking the vials to prevent drying-out soon resulted in the death of the nema. Cotton plugs are better.

I have placed clean paper in each tube to supply cellulose for the termites as long as they remained alive, but they are delicate insects and do not live more than 10 or 12 days when removed from their colonies and placed in small containers.

During about 3 weeks of study in Menado and vicinity I found nematodes in termites as follows:

Cryptotermes (1 species) ....No nema
Eutermes (3 species) ....No nema
Termes (small species) ....
....Nema in abdominal cavity of small workers. Rarely in head.
Termes (large species) ....No nema
Neotermes (1 species)....................Nema in head of soldiers.
Microcerotermes (1 species) ....
................Nema in head and abdominal cavity of workers.
Coptotermes (1 species) ....
.......Nema common in head of workers. Only one colony found.

During dissections of the small workers of *living termes,* I twice found a *Dipterous* larva distinctly occupying the abdominal cavity and filled with globules of the termite fat-bodies. However, of the many termites which I placed in tubes with soil subsequent to that, no flies have developed excepting Phorids, which occasionally get into the tubes and oviposit on the dead termites. I have found no more in the dissections. This was quite obviously a parasite and probably a Phorid.

The nema which occur in the abdominal cavity of the small workers of *Termes* and workers of *Microcerotermes* are distinctly not within the intestinal tract. By dissecting in water, the entire alimentary canal, excepting the oesophagus, could be easily removed intact. I found the nema lying free on the surface of the intestine and quite active. Usually only from 1 to 4 were present. They were very small (about ½ mm. in length). They evidently cause a premature death of the termite and complete their development in the decaying body of the host after it dies. By placing from 50 to 100 of these termites in a clean tube with a bit of clean paper for them to cling to, minute nema usually appeared on a few of those that died, soon grew to about 1½ mm. in length, mated and then very rapidly multiplied. Usually in 10 day's time all the termites would be dead and swarming with nematodes. The same happened with those species of termites in which the nema occur in the heads.

When clean termites were placed in tubes containing sterile soil, with paper, the same nema development occurred in the tubes in about 7 to 10 days' time. No nema development appeared in tubes containing species of *Eutermes, Cryptotermes* (1 sp.), and one large species of *Termes* and no nema were ever found in the dissections of these.

The small species of *Termes,* in which nema occurred in the small workers, did not always have nema in the colonies. Only one colony of *Coptotermes* was found and most of the workers taken from this colony had from 3 to about 8 nema per head. I cannot say that *Coptotermes* is rare in North Celebes, however, for I collected only for about 3 weeks.

The nema from these termites do not seem to be soil nema, for no development in the tubes containing termites, with soil, exceeded that in tubes containing termites but no soil. I am shipping some in soil only in the hope that in these the moisture will be retained better.

I have noted a quick mortality among all workers of *Termes* when placed in a large jar of soil in which I had succeeded in developing a large quantity of nema. This mortality occurred with two separate, inserted lots within 3 days. As the jar contained only soil, paper and thousands of nema, I could ascribe the early mortality only to the nema, which went on increasing until all of the termite substance was gone.

If any nema arrive alive in the shipment, I would suggest that they be allowed to increase in the tubes, by the insertion of *Coptotermes,* until abundant. Then fresh *Coptotermes* could be placed in for a day or two to allow infection and then replaced, living, in the colonies where they were collected.

I have not seen enough of the work of these nema to know of what value they are. I hardly think the Tyroglyphid mite is of any importance.

The ant which I mentioned in my last letter as a possible termite enemy does not seem to be definitely dependent on termites for food, though it is the only species I found about Menado that very commonly occurs intermingled with the termites in their colonies.

I found no further parasites of *Rhabdocnemis* in North Celebes and have not felt sufficiently encouraged in my findings there to remain longer.

I have only just arrived at Makassar and will investigate *Rhabdocnemis* in this region first before leaving for Borneo.

[Note. We have succeeded in rearing one generation of one of the nematodes on *Coptotermes,* but the difficulty is to find nests to experiment with as whenever found they are at once destroyed by fumigation. F. M.]

The Length of Life of Seed-Piece Roots and The Progress of Sugar Cane Roots in the Soil at Different Ages of Growth

By H. Atherton Lee and D. M. Weller

Introduction

During the course of growth-failure studies it has become apparent that to understand the degree of injury and nature of various factors affecting the roots, an understanding of the normal roots is first essential. Some progress is being made in developing knowledge of the normal roots and one step in such progress has resulted from the following experiments.

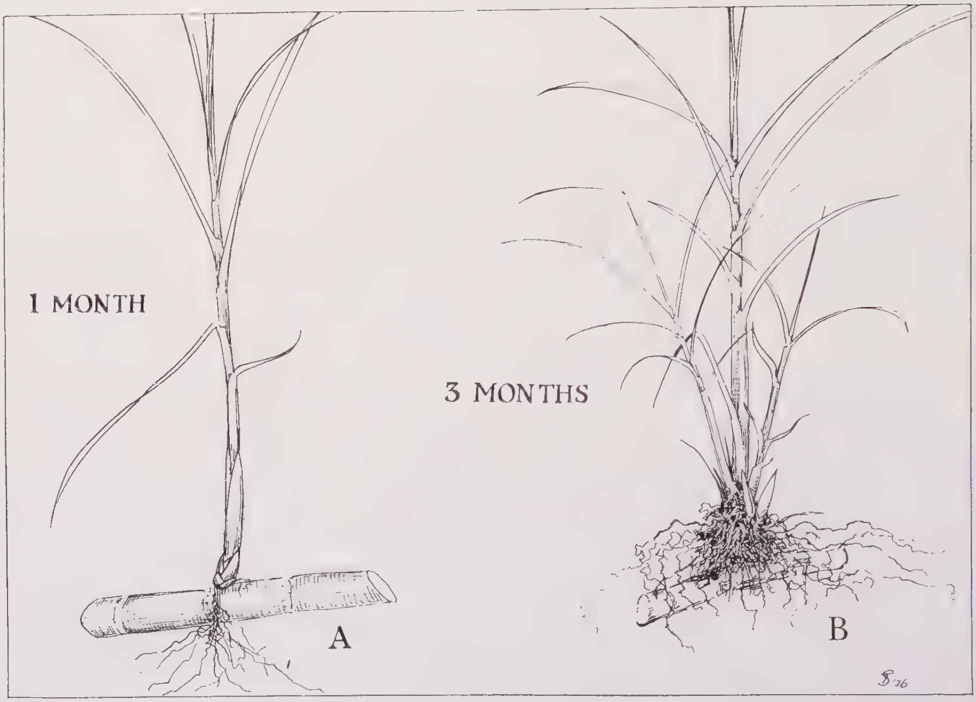


Fig. 1. A sketch attempting to illustrate the method of formation of roots in the early stages of the cane in the experiments. The bud of the cane cutting germinates to form a stalk and at the same time the root eyes of the cutting germinate to form roots. The stalk does not form its own roots until it has formed its first cane node and then produces roots from the root band at the node. Plant A, 1 month old, shows seed-piece roots formed almost exclusively, while plant B, 3 months old, shows stalk roots preponderating over seed-piece roots. The present experiments show that at the end of one month 97.3 per cent of the roots are formed from the seed pieces and only 2.7 per cent of the roots from the stalk. At the age of one month, therefore, the stalk is drawing nearly 100 per cent of its nutrients through the seed piece from the seed-piece roots. In the case of the 3 months old cane but 1.2 per cent of the roots consist of seed-piece roots and 98.8 per cent consist of roots given off from the root bands of the lowest nodes on the newly formed cane stalk. Thereafter the roots from the seed piece gradually decrease in weight until they are negligible and the seed piece decays.

As is perhaps commonly known, a seed piece of sugar cane, when it is first planted, puts out roots from the root bands at the same time that the eyes germinate. The eye grows into an aerial shoot, but it is some time before such a stalk forms its own roots, and during this period it draws its nutrients from the seed piece and through the seed piece from the seed-piece roots. By referring to Fig. 1, this can be more readily understood.

The experiments recorded here show the period in the life of normal cane, when these seed-piece roots function and the period at which the new cane plant puts out its own roots and functions for itself. The downward progress of the roots into the different levels in depth in the soil is also shown from these studies.

Methods of Study

Fifteen root-study boxes having the removable sides and horizontally placed wire netting as previously described (*Hawaiian Planters' Record*, Vol. XXX, No.

Fig. 2. Showing the character of the box in which the cane is grown. The sides of the box have been removed and the soil washed away, leaving the roots suspended in position on the wire netting. The cane at this age (one month from planting) averaged 97.3 per cent of its roots originating from the seed piece and 2.7 per cent originating from the aerial shoot or stalk.

TABLE I

Showing the weights of the roots from the stalks as compared with the weights of the seed-piece roots at different periods of growth; the cane was H 109, and the results below are the averaged weights from three plants of each age.

Levels in Depth.	Cane 1 Month Old.					Cane 2 Months Old.					Cane 3 Months Old.					Cane 4 Months Old.					Cane 5 Months Old.				
	Stalk roots.		Seed-piece roots.		Total both classes of roots.	Stalk roots.		Seed-piece roots.		Total both classes of roots.	Stalk roots.		Seed-piece roots.		Total both classes of roots.	Stalk roots.		Seed-piece roots.		Total both classes of roots.	Stalk roots.		Seed-piece roots.		Total both classes of roots.
	Grams.	Pct.	Grams.	Pct.	Grams.	Grams.	Pct.	Grams.	Pct.	Grams.	Grams.	Pct.	Grams.	Pct.	Grams.	Grams.	Pct.	Grams.	Pct.	Grams.	Grams.	Pct.	Grams.	Pct.	Grams.
Topmost 8 inches	.036	4.0	1.094	96.	1.130	9.58	72.5	3.62	27.5	13.20	96.75	98.2	1.77	1.8	98.52	150.2	99.3	1.0	0.7	151.2	229.0	99.7	0.6	0.3	229.6
8 to 16 inches.	.00	0.0	0.162	100.	0.162	2.66	88.3	0.35	11.7	3.01	29.63	100.	0.00	0.0	29.63	48.6	100.	0.0	0.0	48.6	61.2	100.	0.0	0.0	61.2
16 to 24 inches.	.00	0.0	0.025	100.	0.025	0.94	100	0.00	0.0	0.94	14.11	100.	0.00	0.0	14.11	27.0	100.	0.0	0.0	27.0	25.4	100.	0.0	0.0	25.4
24 inches downward.	.00	0.0	0.003	100	0.003	0.33	100.	0.00	0.0	0.33	9.27	100.	0.00	0.0	9.27	24.0	100.	0.0	0.0	24.0	17.4	100.	0.0	0.0	17.4
Totals.	.036		1.284		1.320	13.51		3.97		17.48	149.76		1.77		151.53	249.8		1.0		250.8	333.0		0.6		333.6
Percentages of class in total		2.7		97.3			77.3		22.7			98.8		1.2			99.6		0.4			99.8		0.2	

2; April, 1926; page 267), were planted each with one seed piece of the variety H 109. These seed pieces were selected for uniformity in length of internodes, diameter and position on the stalk. They had previously been cut to three-eye seed pieces and gouged so as to leave only the middle eye. At time intervals of one month three of the boxes were selected in consecutive order according to their position, the sides removed and the soil washed away from the roots of the cane in each box. The roots of the cane were thus left in correct position suspended on the wire netting. The photograph reproduced in Fig. 2, shows the type of root-study box in use.

At different levels in depth in the soil, beginning at the bottom and working upwards, the roots were cut off; thus all the roots below the 24-inch level in depth were first cut off and collected. Next the roots between 16 and 24 inches in depth were cut at the 16-inch level, and collected; the roots between 8 and 16 inches in depth were next collected and then the roots between the soil surface and 8 inches in depth. In collecting these roots, those which emanated from the seed piece were carefully separated from the roots originating from the stalk. The separate root collections were then washed more carefully to remove all traces of soil, oven-dried and weighed.

The Relation of Seed-Piece Roots to Stalk Roots

Table I shows the weights of the seed-piece roots as compared to the weights of the stalk roots.

The results recorded in Table I show that the cane plant functions entirely by the use of the roots from the seed piece for one month; at the end of one month 97.3 per cent of the total roots originated from the seed pieces while only 2.7 per cent of the roots originated from the stalks of the aerial shoots. At the end of two months the situation had changed considerably, only 22.7 per cent of the roots having arisen from the seed piece compared with 77.3 per cent of the roots from the stalks of the aerial shoots. At the end of the third month the situation was completely reversed, with only 1.2 per cent of the roots emanating from the seed piece and 98.8 from the stalks of the aerial shoots. Thereafter the roots from the seed piece constituted but a negligible proportion of the total roots. The relation of the weights of seed-piece roots to the weights of stalk roots at different ages of growth is shown graphically in Fig. 3.

THE PERCENTAGES OF SEED-PIECE ROOTS AS COMPARED TO AERIAL-SHOOT OR STALK ROOTS AT DIFFERENT AGES IN THE CANE GROWTH

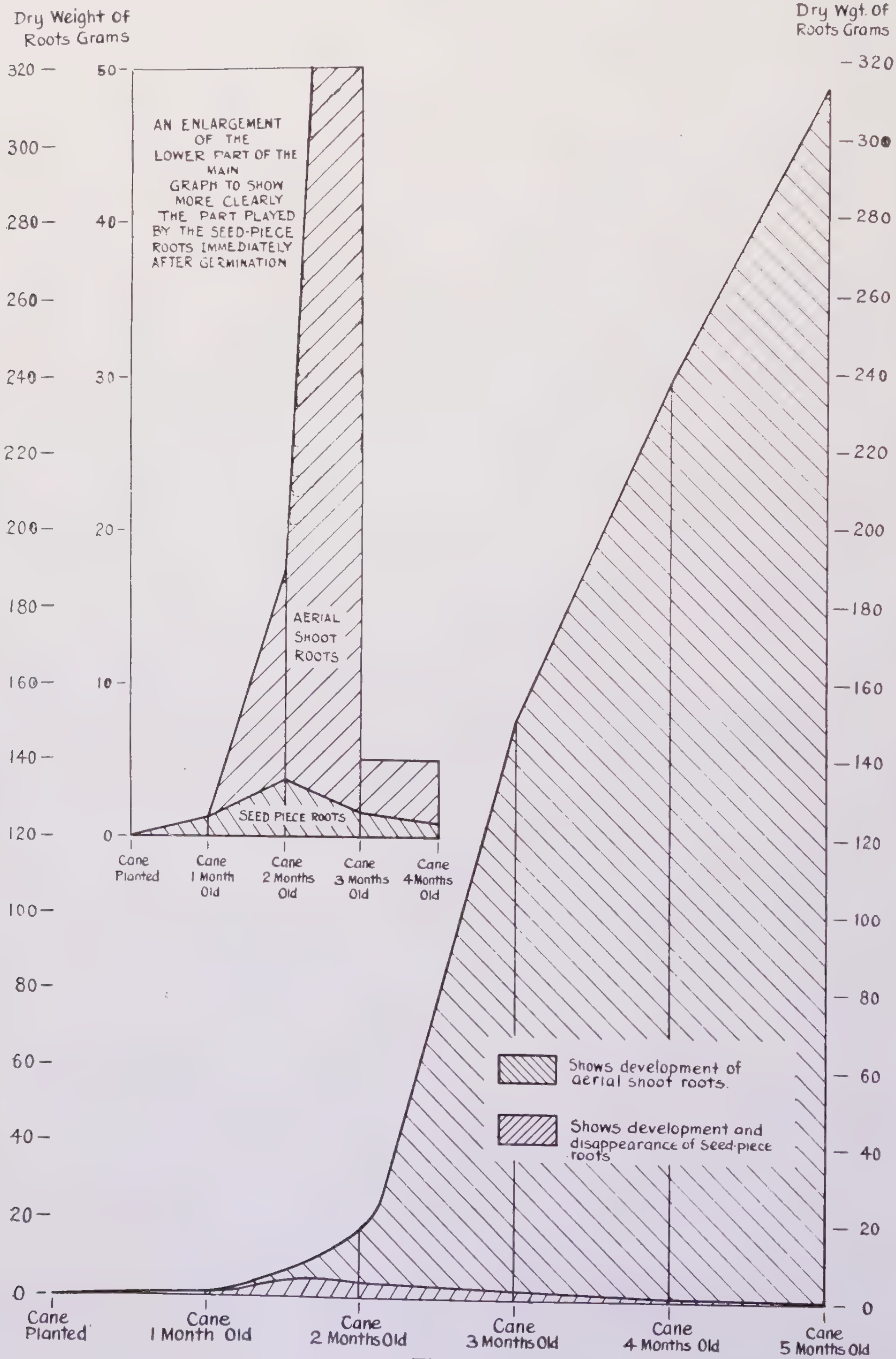


Fig. 3

It is of interest that this change in the proportion of stalk roots to seed-piece roots was not due alone to the increased weight of the stalk roots; after the second month the seed-piece roots did not increase but actually decreased in weight. At the end of the fifth month the seed-piece roots weighed but 6/10ths of a gram as compared to 333 grams of stalk roots, amounting to but 2/10ths of one per cent of the total roots.

Therefore under normal conditions *apparently the seed-piece roots alone furnish the nutrients for the stalk for the first month. After the first month and to the end of the second month there is a transition period during which the burden of supplying nutrients shifts from the seed-piece roots to the stalk roots. At the end of the third month and thereafter the burden of supplying nutrients rests almost entirely on the stalk roots since the seed-piece roots have disappeared.*

Discussion

It has been argued from these data that fertilizers should not be applied to the cane until the stalk puts out its own roots, and that fertilizers applied to seed-piece roots, will only stimulate roots which will very shortly die and roots will be built up only to be wasted. More careful analysis would indicate there are reasons for early applications of fertilizers, which outweigh the foregoing. The stalk cannot form its own roots until it has formed at least one node and the accompanying root band at that node. Thus, fertilizers applied early will stimulate the formation of the first node on the stalk and hasten the formation of the first aerial-shoot roots. That part of the fertilizer which is not used by the seed-piece roots will remain for utilization by the stalk roots. That part of the fertilizer used in the formation of the seed-piece roots will not be lost, but on the decay of the seed-piece roots will be returned to the soil.

One would expect, therefore, that experiments with nitrogen and potash in the furrow, as well as phosphoric acid, would possibly result in interesting data.

In connection with root-rot studies there is an important conclusion to be drawn, namely, *that rots of the seed-piece roots after the first month of growth, should be distinguished from rots of the roots from the cane stalk; the decomposition of the former would seem to be more or less the natural life processes of the cane plant* while, of course, rots in the stele of the roots of the cane stalk would be decidedly abnormal.

The Progress of the Roots at Different Ages of Growth

In addition to the data showing the comparative weights and proportions of seed-piece roots and stalk roots, data were obtained showing the development of roots of both classes in the different levels in depth in the soil at different ages of the cane. These data are recorded in Table II, showing the weights of the cleaned, oven-dried cane roots in the different levels in depth in the soil at the different periods in the age of the cane. The figures below show the combined weights of both seed-piece roots and the roots formed by the stalk; weights are in grams, and are the averages of three plants of each age.

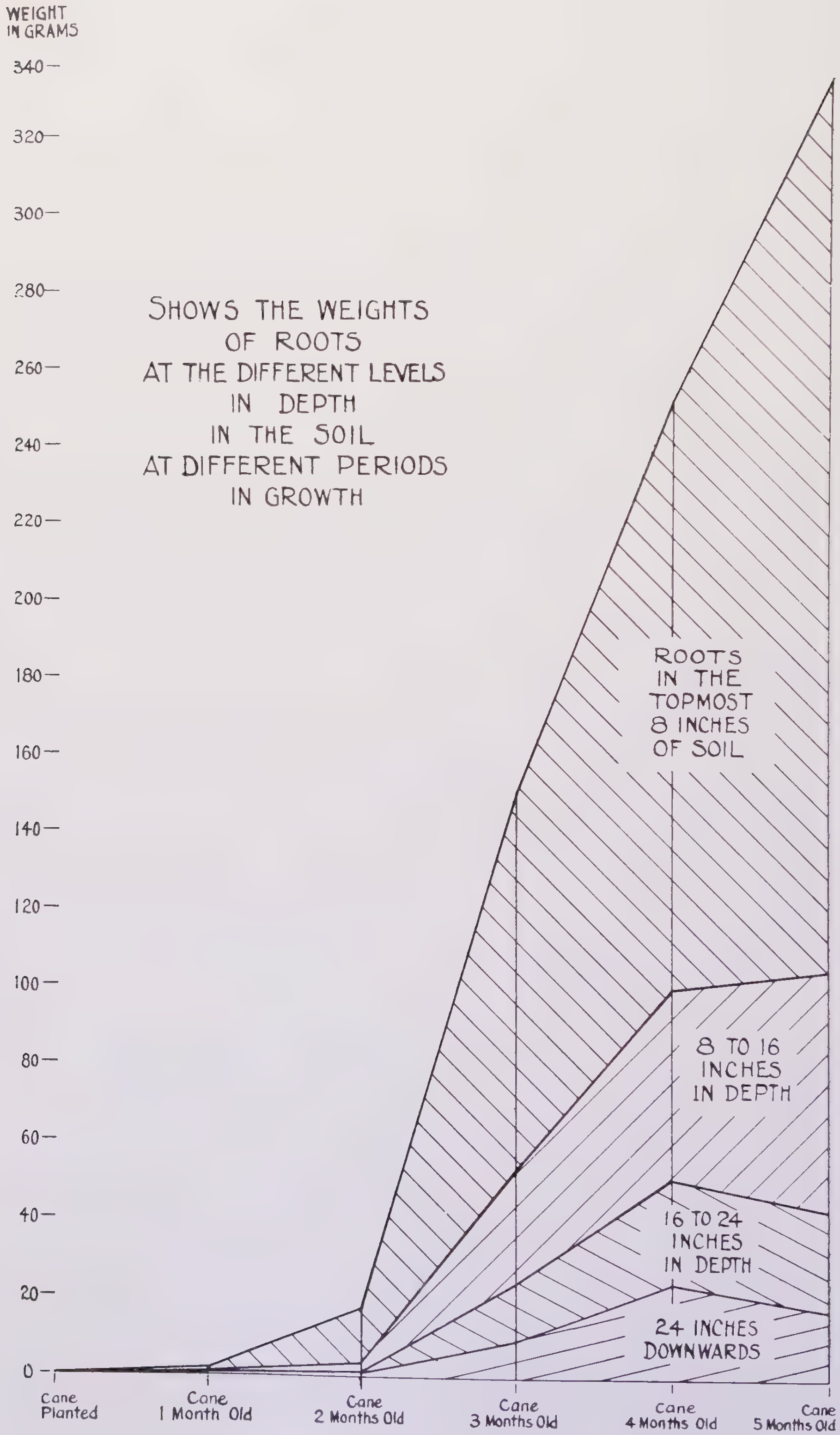

WEIGHT
IN GRAMS
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
SHOWS THE WEIGHTS
OF ROOTS
AT THE DIFFERENT LEVELS
IN DEPTH
IN THE SOIL
AT DIFFERENT PERIODS
IN GROWTH
ROOTS
IN THE
TOPMOST
8 INCHES
OF SOIL
8 TO 16
INCHES
IN DEPTH
16 TO 24
INCHES
IN DEPTH
24 INCHES
DOWNWARDS
Cane Planted
Cane 1 Month Old
Cane 2 Months Old
Cane 3 Months Old
Cane 4 Months Old
Cane 5 Months Old

Fig. 4

TABLE II

WEIGHTS OF ROOTS AT DIFFERENT LEVELS IN DEPTH IN THE SOIL AT DIFFERENT AGES OF THE CANE

Levels in Depth	1 Month Wgt.	1 Month Pct.	2 Months Wgt.	2 Months Pct.	3 Months Wgt.	3 Months Pct.	4 Months Wgt.	4 Months Pct.	5 Months Wgt.	5 Months Pct.
Topmost 8 inches ...	1.130	85.6	13.20	75.5	98.52	65.0	151.2	60.3	229.6	68.8
8 to 16 inches	0.162	12.2	3.01	17.2	29.63	19.5	48.6	19.4	61.2	18.3
16 to 24 inches	0.025	1.9	0.94	5.3	14.11	9.3	27.0	10.7	25.4	7.6
24 inches downward.	0.003	0.3	0.33	1.9	9.27	6.1	24.0	9.5	17.4	5.2
Totals	1.320	100.0	17.48	99.9	151.53	99.9	250.8	99.9	333.6	99.9

Examining the figures showing weights first, the results indicate what would naturally be expected, i. e., that the cane weights increased with age, and that the upper levels of the soil were first penetrated and the lower levels then penetrated successively. The weights of the roots in the different levels in depth at the different ages in growth are shown graphically in Fig. 4.

The figures concerning percentages of roots are fully as important as the figures for root weights, for in the application of fertilizers and irrigation water, one wishes to place such applications where the largest proportion of the roots exist, and total weights are not as relevant in such questions as are the percentages of roots. If one now refers to the percentages of roots in the different levels in depth in the soil as shown in Table II, it can be seen that starting with 85 per cent of the roots at the end of the first month *the proportions of the roots in the topmost 8 inches of soil gradually decreased until about 60 per cent of the roots were found in this level; the curve of the decrease then leveled off, and it is expected that the plants maintain somewhere between 55 and 70 per cent of their roots in this stratum until maturity*, at least the results of field root studies support such a view. At the same time *the percentages of the roots in the lower strata increased to a given proportion and the curve of increase then appeared to level off giving a more or less fixed proportion of the roots through to maturity.* The graph shown in Fig. 5 illustrates this approach to fixed proportions of root quantities in the different levels in depth in the soil, after the first few months of growth.

It seems to us established from these studies, supported by field studies not yet reported, that water and nutrients to reach the greatest proportion of roots should be directed towards the uppermost 16 inches of soil where more than 75 per cent of the roots usually exist. Our first impression, and that of many others when our data are first seen, that tillage before planting, also need only be shallow, seems to us not entirely warranted. With this work on roots we have come to the opinion that, given optimum moisture and nutrients, the outstanding factor for formation of the important secondary roots with their large proportion of

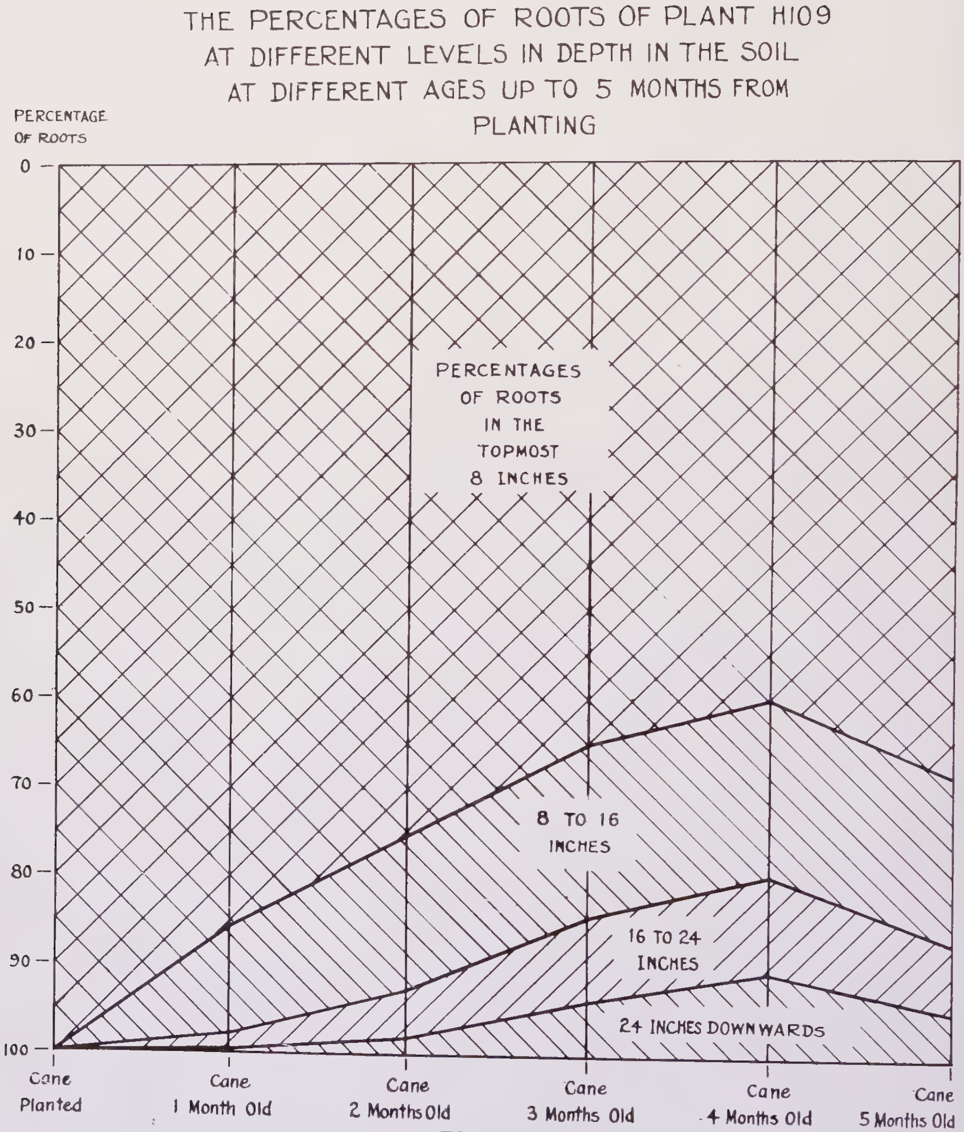


Fig. 5

feeding surfaces, is soil aeration. We do not have quantitative data to support this opinion; our views are based upon field observations only and we present these views as opinion only. If this opinion is correct then deep tillage and organic matter before planting would improve aeration and would improve and increase the feeding surfaces of the roots, and thus indirectly increase cane tonnage. The results are suggestive of field experiments to test root formation and cane tonnage with increased soil aeration as compared with control conditions.

Mr. H. P. Agee, also brings forward the suggestion that these data offer additional evidence in support of the modern idea that cultivation between the rows of growing crops has value chiefly in the function of weed control. Much

experimental work, locally with cane, and on the mainland with corn and other crops, shows that in the great majority of instances the damage to surface roots from such cultivation more than offsets whatever benefits may take place.

A Comparative Study of the Determination of Potash in Cane Juice by the Gravimetric and Sherrill Methods

By L. E. Davis and G. R. Stewart

Introduction

Ever since the early workers in soil fertility clearly demonstrated the need which plants have for mineral nutrients, there has been keen interest manifested in methods which could be used to determine the availability of these nutrients in the soil. The first work centered on the use of various weak solvents to dissolve out the more available soil materials. Water, both plain and carbonated, dilute citric acid, acetic, hydrochloric and nitric acids have all been employed. Dyer's (2) method employing one per cent citric acid has had very wide application, and our work in Hawaii has shown considerable value for the results obtained by this procedure.

A number of continental investigators have studied the possibility of determining the supply of available materials in the soil by the analyses of plant ashes. Hall (3) at Rothamsted carried on work along this line which led him to conclude that the significance of the figures obtained would vary with the crop. He did not find that the ash of cereals varied significantly, if grown on either good or poor soils. On the other hand, the potash content of the ash of mangel and swede, stock beets, gave a valuable indication of the needs of the soil for potash fertilization. Lately, Hoffer (4) working in Indiana has proposed that the fertilizer requirements of the corn plant can be found by making colorimetric tests on the tissues of the partly mature corn stalks.

Here in Hawaii, Walker (6) working at Pioneer Mill Company, reported a series of determinations of the phosphate content of the crusher juice. The samples reported covered both the upper fields, where it was believed phosphoric acid fertilization was required, and the lower land where the supply of phosphates was considered to be adequate. From this data, Walker suggested a tentative set of figures prescribing the limits of phosphate content of the juice which might indicate a deficiency or a good supply of phosphates in the soil. This work on the phosphate content of the juice has now been taken up on many of the Hawaiian plantations. The results to date indicate that information of considerable value may be obtained as to the phosphate supply of the soil. This is especially true

if phosphate plot tests are carried on in typically good and poor plantation fields, and the juice sampled when the plots are harvested.

The next step was to try to obtain some information as to the potash supply of the soil by determining the potash content of the crusher juice. For this purpose a modification of Sherrill's (5) centrifugal cobaltic nitrite method has been employed as published in the methods for chemical control of the Association of Hawaiian Sugar Technologists, 1924. Certain discrepancies have appeared in the results obtained by this method, especially when it has been further modified in the plantation laboratories. The accuracy of the Sherrill method for this purpose has been questioned, so a comparison of the Sherrill procedure with the official gravimetric chloroplatinic method (1) appeared to be desirable. Certain modifications of the Sherrill method, which have been tried in one of the plantation laboratories, have also been studied.

Sherrill Method Modified by Hawaiian Technologists Association

The Sherrill method, as given on page 54 of the Methods of Chemical Control of the Hawaiian Sugar Technologists Association, 1924, is as follows:

The Sherrill centrifugal method is based upon the relative volume of precipitate in two solutions, one of known potash content.

Standard 1 Per Cent K_2O Solution: Weigh carefully 15.83 gm. of C. P. Potassium Chloride, dissolve in distilled water in a liter volumetric flask, add 8 or 10 drops of glacial acetic acid and dilute to 1000 c.c. with distilled water.

Sodium Cobaltic Nitrite Solution: To 225 gm. C. P. sodium nitrite ($NaNo_2$), add 400 c.c. distilled water and allow to stand over night with occasional stirring. At the same time dissolve 125 gm. C. P. cobalt acetate in 400 c.c. distilled water. When the sodium nitrite is all dissolved, pour the cobalt acetate into it and mix thoroughly by pouring repeatedly from one beaker to the other. Then dilute to 1000 c.c. with distilled water. This solution keeps very well for several months. A precipitate may form on long standing, but has no harmful effect, as it entirely dissolves when the stock solution is diluted and acidified for use.

Prepare a solution for use by adding to 100 c.c. of the above, 65 c.c. distilled water and 5 c.c. glacial acetic acid and mix by shaking. Remove the gases given off by placing under vacuum for one hour, or by standing over night in a loosely stoppered bottle. Sodium cobaltic nitrite does not keep well after it is acidified, so it is best to make up one day's supply at a time.

Centrifuge: Use a Babcock milk testing hand centrifuge with a four tube head fitted with cork liners to take centrifuge tubes of the "Sherrill" potash type. Calibrate the tubes as follows: using a 1 c.c. pipette graduated in 0.01 c.c. transfer 0.3 c.c. of mercury to one tube. The mercury can be made to go down into the stem by using the capillary washing tube. The 0.3 c.c. should fill the tube to the 15 mark. Transfer this mercury through a funnel from one tube to another, and note the necessary corrections for each tube. The capillary washing tube must be small enough to reach to the bottom of the centrifuge tube. It is made by drawing a piece of glass tubing to a sufficiently small diameter. It should be connected to a large wash bottle and is used to wash the precipitates out of the tubes.

Procedure: Determine the degree Brix of the juice and from this the specific gravity. To about 500 c.c. of juice add milk of lime to faint phenolphthalein alkalinity. Heat just to boiling and filter through a dry Buchner funnel, using suction. Pipette 150 c.c. of the clarified juice, which must be bright and free from suspended and colloidal matter, into a 400 c.c. beaker. Evaporate to less than 50 c.c. on water bath or hot plate. Trans-

fer to a 50 c.c. volumetric flask, add 2.8 c.c. of glacial acetic acid and make up to 50 c.c. after cooling to room temperature which should be above 72° F.

Transfer 17 c.c. of the sodium cobaltic nitrite solution to each of two centrifuge tubes. Be sure that the stems are full of water and contain no air bubbles, before adding the nitrite solution. To one tube add 5 c.c. of the standard 1 per cent K_2O solution, and to the other 5 c.c. of the prepared sample. Centrifuge at once for one minute, at 1000 r. p. m. Allow the machine to come to a stop, remove each tube, level the precipitate by tapping the stems gently with the finger, replace in the machine, centrifuge for 15 seconds more and read the volume of the precipitate.

$$\text{Per cent } K_2O = \frac{50 \times \text{Reading of juice}}{150 \times \text{Sp. Gravity Juice} \times \text{Reading of Standard } K_2O \text{ solution}}$$

Juices which are very low in K_2O, and which do not give a reading sufficiently close to that of the standard, to be reliable, should be run again, using 10 c.c. of the sample in one tube and 5 c.c. of the standard K_2O solution, with 5 c.c. of distilled water in the other. In this case, divide the figure obtained by the above formula by 2.

The standard K_2O solution does not give constant readings, due to temperature differences and the age of the sodium cobaltic nitrite solution. Hence it is necessary to run a tube of the standard with every sample, or set of samples. If room temperature is below 72° F., gently heat the cobalt solution to 85°, so that the temperature of the liquid in the tubes will be over 72° when the determination is finished. It is essential that the concentrated sample be bright and contain no precipitated or suspended matter after the acetic acid is added. If this is not the case, further clarification must be obtained by acidifying the filtrate from the lime clarification, heating and again filtering before taking the 150 c.c. for analysis. For comparative purposes, the specific gravity of the juice may be neglected and the results expressed as grams K_2O per 100 c.c. juice. For a more detailed description of the method and its application to other potash containing materials see "Sugar," Vol. 23, May-June, 1921.

Previous work carried on in this laboratory by Hansson has shown that the Sherrill method is not sufficiently accurate to rely on it for the determination of potash in fertilizer samples. A similar study by McGeorge demonstrated that it could not be used for soil extracts, owing to the interference of soluble minerals and the difficulty of obtaining a solution which would contain approximately 1 per cent K_2O.

The proposed use of the Sherrill method for the determination of the potash content of the cane juice would not call for the absolute accuracy, which would be necessary in a procedure used in fertilizer control work. The plantation agriculturist is interested in the relative content of potash furnished to the cane plant by his better and poorer soils. So long as a method gives a correct relative measure of the potash present in the juice, it would not be significant if the figure obtained were either slightly higher or lower than the exact amount present. Such a control procedure should give consistent differences from the truth, without too great fluctuations between duplicates, if the results are to be considered reliable.

Manipulation of the Sherrill Method

As a preliminary to the comparison of the Sherrill method with the gravimetric procedure, a careful study was made of the method of manipulation and of the conditions which it is necessary to observe in order to obtain satisfactory duplicate

determinations upon solutions of known potash content. The following points were found to be important:

In preparing the dilute solution of sodium cobaltic nitrite acidified with acetic acid, it is necessary to make a fresh supply of this solution for each day's use. The gases formed upon mixing the above solution must be completely evacuated from the bottle by the use of suction. It is not adequate, as suggested in the method, to allow the solution to stand over night in a loosely stoppered bottle.

The centrifuge should be run at as nearly a constant speed as possible when making the precipitation in the Sherrill tubes. It would probably be desirable to use an electric centrifuge, with steady voltage, in order to obtain uniform packing of the precipitates.

It was found that the precipitates formed by the standard 1 per cent K_2O solution did not settle so well as those given by the usual cane juices. This made the comparison between the standard and the determination uncertain and difficult. Some of the plantation laboratories have attempted to overcome this difficulty by using a different strength of standard solution. A careful trial of these modifications showed that the standard suggested in the outline, namely 1 per cent K_2O, is to be preferred. The following slight modification appeared to aid in obtaining concordant results: Transfer 17 c.c. of the sodium cobaltic nitrite solution reagent to each centrifuge tube. Add 5 c.c. of a 1 per cent K_2O solution, made up from KC1, to one tube and 5 c.c. of solution from each prepared sample, containing approximately 1 per cent of K_2O, to each of the other tubes. Mix the contents of each tube thoroughly. Centrifuge for one minute at 1000 r. p. m. Free the precipitate adhering to the upper walls of the tubes with a rubber policeman. Add a few drops of ether and centrifuge again for one minute.

Comparison of Sherrill and Gravimetric Methods for the Determination of Potash in Cane Juice

A comparison was first made between the determination of potash in a set of juice samples, from one of the Oahu plantations, by the official gravimetric method, and by a modification of the Sherrill. The gravimetric determinations were made in the chemical laboratory of this Station and those by the Sherrill procedure were made in the plantation laboratory. The Sherrill determinations were made by a modification in which a ¼ K_2O solution was used as the standard and the juice sample used was the clarified solution, without further concentration. The comparison of these two sets of analyses is given in Table I. It will be seen that there is a very poor agreement between the two methods. In some cases the variation amounts to as much as 100 per cent difference between the two.

TABLE I

Comparison of Potash Content of Cane Juice by Gravimetric and Sherill Methods

Sample Number	Field Number	Date 1926	Solids by Brix	Per Cent K_2O In Juice Gravimetric H. S. P. A. Laboratory	Per Cent K_2O In Solids Gravimetric H. S. P. A. Laboratory	Per Cent K_2O In Solids Sherrill Modified Plantation Laboratory
1	25A-29	June 30	19.30	0.219	1.13	0.71
2	25A-1	July 2	19.81	0.163	0.82	1.20
3	25A-1	July 3	19.73	0.204	1.03	2.28
4	25D-28	June 30	18.38	0.274	1.49	2.40
5	24A-29	July 1	19.28	0.177	0.92	0.61
6	24A-2	July 3	18.98	0.195	1.03	0.47
7	24A-3	July 7	19.18	0.186	0.97	0.31
8	24B-29	July 1	19.30	0.141	0.73	2.41
9	24B-1	July 2	19.55	0.146	0.75	0.36
10	24B-2	July 3	19.62	0.141	0.72	2.35
11	3D	July 13	19.60	0.151	0.77	0.55
12	3D	July 14	19.20	0.158	0.82	0.41
13	3D	July 15	19.20	0.168	0.87	0.66
14	24B	July 7	20.00	0.156	0.78	...
15	24A	July 12	20.00	0.180	0.90	0.85
16	24A	July 13	19.80	0.194	0.98	0.55
17	24A	July 14	19.00	0.189	1.00	0.78
18	24A	July 15	19.00	0.189	0.99	0.42
19	24C	July 9	19.90	0.188	0.94	...
20	24C	July 10	19.30	0.203	1.05	...
21	24C	July 14	18.90	0.162	0.86	0.51
22	25A	July 7	20.60	0.219	1.06	1.71
23	25A	July 8	20.20	0.195	0.96	2.11
24	25A	July 9	20.80	0.242	1.16	...
25	25A	July 10	19.80	0.247	1.25	...
26	25A	July 12	20.30	0.240	1.18	1.57

A second set of juice samples was obtained from the same plantation. Upon these samples the potash was determined as before by the gravimetric method. Determinations were also made in this laboratory by the regular Sherrill method, with the slight modification noted earlier in this paper. The results of these determinations are given in Table II, and are compared with the results obtained by the plantation laboratory using the same modification of the Sherrill procedure. It will be seen that there is a fairly good agreement between the gravimetric determinations and those made by the regular Sherrill procedure. The Sherrill determinations would not be satisfactory if one desired an extremely accurate estimation of the potash. For a rapid control method, however, the results indicate that the method is applicable. The results by the plantation modification are slightly better than on the previous set of samples, but there are again a number of cases where the difference between the modified Sherrill determination and the gravimetric amounts to over 100 per cent variation.

A final set of juice samples was obtained from Waimanalo Sugar Company. Here the plantation was not making a determination of potash. All the compara-

tive results were obtained in this laboratory. Determinations of potash were made on all samples by the gravimetric and regular Sherrill methods. On half of the samples, determinations were also made, using the previous plantation modification. The results are given in Table III. There is again a fairly good agreement between the gravimetric results and the regular Sherrill procedure, while the results are less accurate by the modification of the Sherrill test. It should be pointed out that there are a few discordant results obtained by the regular Sherrill procedure, but the number of these discrepancies, in our analyses, is not large. We believe these occasional discrepancies would indicate the desirability of checking any unusual Sherrill determinations, gravimetrically.

Summary

A comparison has been made of the determination of potash in cane juice by the official gravimetric method, the regular Sherrill centrifugal procedure and a modification used by one of the plantation laboratories.

In general there was a moderately good agreement, for control purposes, between the gravimetric determinations and the regular Sherrill figures. The plantation modification resulted in a notable loss of accuracy.

Occasional discrepancies between the gravimetric and Sherrill procedure suggest the desirability of occasionally checking unusual results obtained by the Sherrill, with gravimetric determinations.

A few precautions are necessary to ensure accuracy with the Sherrill method. The most important of these were found to be:

The centrifuge should be operated at as near 1,000 revolutions per minute as possible.

The gases formed on mixing the sodium cobaltic nitrite with acetic acid should be evacuated from the container by suction.

A 1 per cent K_2O solution should be used as the standard with each set of potash determinations.

It was found that the standard determinations frequently do not pack down properly in the tubes. Proper packing was facilitated by rubbing down the upper walls of the vessel with a rubber policeman, after the first period of centrifuging, adding a few drops of ether and centrifuging a second time for one minute.

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TABLE II

Comparison of Potash Content of Cane Juice by Gravimetric and Sherrill Methods

Sample Number	Field Number	Date 1926	Per Cent K_2O in Solids Gravimetric H. S. P. A. Laboratory	Per Cent K_2O in Solids Sherill H. S. P. A. Laboratory	Per Cent K_2O in Solids Sherrill Modified Plantation Laboratory
27	24-C	August 16	0.53	0.61 0.62	0.40
28	3-D	August 16	0.73	0.79 0.79	0.55
29	3-C	August 17	0.59	0.76 0.75	1.39
30	3-D	August 17	0.83	0.77 0.76 0.85	1.10
31	3-D	August 19	0.63	0.66 0.70 0.78	1.13
32	3-C	August 19	0.52	0.56 0.56 0.58	0.63
33	3-C	August 19	0.70	0.74 0.74	0.42
34	3-D	August 19	0.70	0.86 0.79	0.60
35	3-C	August 20	0.61	0.69 0.72	0.68
36	C	August 21	1.03	1.17 0.99	0.76
37	C	August 21	1.00	1.01 1.04	0.74
38	3-C	August 21	0.70	0.90 0.92	0.83
39	C	July 24	1.01 1.02	1.05 1.08 1.08	0.51
40	3-C	July 24	0.80 0.80	0.73 0.76 0.79	0.33
41	25-C	July 24	1.01 1.02	0.84 0.91 0.91	0.33
42	3-C	July 26	0.81 0.82	0.86 0.85 0.88	0.85
43	25-C	July 26	0.85 0.86	1.02 1.04 1.12	0.68
44	3-C	July 28	0.83 0.81	0.72 0.83 0.90	1.00
45	25-C	July 28	1.24 1.22	1.07 1.11 1.21	0.88
46	25-C	July 29	1.10 1.10	1.11 1.18 1.23	0.41
47	25-C	July 30	1.16 1.15	1.09 1.17 1.20	0.97
48	13-C	August 18	1.55 1.56	1.75 1.81 1.93	1.19
49	13-C	August 19	1.46 1.46	1.65 1.77 1.93	1.09
50	13-C	August 20	1.61 1.60	1.54 1.62 1.75	1.01

TABLE III

Comparison of Potash Content of Cane Juice by Gravimetric and Sherrill Methods

Sample Number	Field Number	Date 1926	Per Cent K_2O in Solids Gravimetric H. S. P. A. Laboratory	Per Cent K_2O in Solids Regular Sherrill Method H. S. P. A. Laboratory	Per Cent K_2O in Solids Modified Sherrill Method H. S. P. A. Laboratory
1	Waimanalo	September 1	1.05	1.06 1.10	1.27 1.29
2	22D	September 1	0.98	0.91 0.95	1.12 1.14
3	22D	September 1	0.85	0.79 0.61	0.72 0.80
4	22D	September 1	0.84	0.76 0.81	0.86 1.16
5	22D	September 1	1.08	1.10 1.11	1.18 1.57
6	22D	September 1	1.20	1.13 1.15	1.21 1.60
7	22D	September 1	0.99	0.94 0.93	1.57 1.57
8	22D	September 1	0.93	0.91 0.88	1.54 1.54
9	22D	September 1	0.99	0.88 0.90	1.51 1.51
10	22D	September 1	2.04	2.00 1.94	2.48 2.69
11	22D	September 1	1.30	1.28 1.25	1.57 1.79
12	22D	September 1	1.26	1.19 1.14	1.48 1.69
13	22D	September 1	0.89	1.00 0.90	1.18 1.27
14	22D	September 1	0.91	0.85 0.89	1.07 1.23
15	22D	September 1	1.33	1.25 1.13	1.21 1.60
16	22D	September 2	1.37	1.05 0.99	1.36 1.44
17	22D	September 2	0.89	1.52 1.28	
18	22D	September 2	0.88	1.02 0.98	
19	22D	September 2	0.76	0.98 0.89	
20	22D	September 2	0.76	1.30 1.31	
21	22D	September 2	1.25	1.07 1.07	
22	22D	September 2	0.95	0.83 0.80	
23	22D	September 2	1.88	1.62 1.65	
24	22D	September 2	1.20	0.74 0.75	
25	22D	September 2	0.99	0.79 0.81	
26	22D	September 2	0.85	0.54 0.48	
27	22D	September 2	1.17	0.56 0.62	
28	22D	September 2	1.35	0.95 1.01	

Report on the Treatment of Settlings and the Oliver Filter

By H. F. Bomonti

The following is a report on the work done during the past year at the Oahu Sugar Company, Limited, in connection with the Oliver Filter. The first part is devoted to the presentation and discussion of the data on the treatment of settlings. The second part of the report gives the operating data secured during a two months' run of the Oliver Filter and also an estimate of the savings which might be realized by a complete installation of Oliver Filters at the Oahu Sugar Company, Limited.

Part I

The Treatment of Settlings

The application of the Oliver Filter to the filtration of settlings depends on the chemical treatment of the settlings. The purpose of the chemical treatment of the settlings is threefold:

First, to improve the filtrability of the settlings to such an extent that a cake of suitable thickness will be formed on the Oliver Filter within a few minutes time.

Second, to produce a permeable cake so that sufficient wash water can be applied within a few minutes to reduce the polarization to a reasonable degree.

Third, to produce a cake which is coherent so that when it is discharged from the filter it will leave the cloth clean.

The Borden Treatment:

John F. Borden, of the Oliver Continuous Filter Company, developed a treatment in 1925 at the Oahu Sugar Company which meets these requirements. This treatment, which the writer calls the "Borden Treatment," is carried out in the following manner: The settlings are first limed to 8.5-8.6 pH. Phosphoric acid is added until the pH of the settlings is reduced to 6.8 pH. Phosphoric acid or acid phosphate can be used with practically the same results. Double superphosphate, which is the cheapest form of acid phosphate salt, was used at the Oahu Sugar Company.

The following points have been studied in connection with the Borden treatment:

1. The effect on the filtrability of the treated settlings when the final pH is either higher or lower than 6.8 pH.

2. The change in P_2O_5 concentration of the filtrate from treated settlings with changes in pH.

3. The shape of the titration curve secured when double superphosphate solution is added to limed settlings.

4. The effect of mechanical handling on the filtrability of treated settlings.

5. The effect of temperature of the treated settlings on the filtrability.

6. The effect of the degree of vacuum on the volume of filtrate secured in a given time cycle, and also on the ease with which the cake leaves the cloth.

7. The effect produced by repeating filtration tests without washing the cloth after each test.

8. The influence of the composition of the suspended solids in settlings on the weight of the cake formed during a given time cycle.

9. The effect of the Borden treatment on the purity of the filtrate.

10. The accuracy of the pH control of the treated settlings.

Experimental Filter Unit:

The experimental filter unit which was used in making these comparative tests, has a filtering surface of one-half square foot. It consists simply of two parts, both circular in shape, with the filter cloth placed between them and clamped together. The vacuum is applied to the lower half in which the filtrate accumulates and is drained into a glass receiver. A wire screen covers the top of the lower half which supports the filter cloth. The upper half is cylindrical in shape and simply holds the settlings during the filtration. A vacuum regulator is in the line so that any vacuum can be maintained. A piece of 10 oz. duck filter cloth was used in all the tests, the cloth being washed after each test.

In all the comparative filtration tests the following procedure was used:

The settlings were poured into the upper half of the filtering unit, filtered for two minutes at 10 inches vacuum; the excess settlings were then poured out and the cake which had been deposited on the cloth was allowed to dry out for two minutes at 15 inches vacuum. The volume of filtrate in the glass receiver was measured. The cake was weighed and the thickness measured. The ease with which the cake left the cloth was noted. The pH of the filtrate was determined with the Experiment Station color charts. Other observations which were desirable at times were made.

The Effect on the Filtrability of the Borden Treated Settlings When the Final pH is Either Higher or Lower than 6.8 pH:

Previous tests made by Mr. Borden indicated that the most satisfactory pH to conduct his treatment was 6.8. The following tests were made to study this point. Settlings were first limed to 8.4-9.2 pH; then acidified with varying amounts of the double superphosphate, so that the final pH values were above 6.9, between 6.6-6.8 pH and below 6.6 pH. A filtration test was made on the untreated, limed and each of the treated settlings. These data have been arranged in the following tabulation:

TABLE I

	Untreated		Limed		Acidified Above 6.9 pH		Acidified 6.6–6.8 pH		Acidified Below 6.6 pH	
	pH	Volume of Filtrate	pH	Volume of Filtrate	pH	Volume of Filtrate	pH	Volume of Filtrate	pH	Volume of Filtrate
		ccs.		ccs.		ccs.		ccs.		ccs.
	7.4	650	9.2	900	7.4	950	6.7	850	...	....
	7.9	620	8.5	775	...	....	6.7	940	6.3	900
	7.3	450	8.7	950	7.0	1050	6.6	1100	...	....
	7.3	400	8.5	940	7.0	1280	...	....	6.4	1200
	...	....	8.8	1150	7.6	1320	6.6	1350	6.4	1300
	7.2	475	8.5	900	7.6	1380	6.8	1350	6.3	1380
	7.6	450	8.8	600	7.6	1200	6.6	1500	...	....
	7.6	450	8.4	1360	7.5	1610	6.8	1700	...	....
	...	...	8.4	840	7.0	1150	...	....	6.2	1150
	...	...	8.4	450	7.3	620	...	....	6.5	730
Averages	7.5	500	8.7	918	...	....	...	....	...	....
"	...	...	8.6	899	7.3	1173	...	....	...	....
"	...	...	...	....	7.5	1250	6.7	1310	...	....
"	...	...	...	....	...	....	6.7	1210	6.3	1193

The averages were made in the following manner: Figures in column 1 were averaged in the regular way. To get an average of column 2 comparable to column 1, only those figures were used which had a corresponding result in column 1. This same method was applied to all the other columns.

Comparing these results to the filtrability of untreated settlings the following increases in per cent filtrability have been calculated:

TABLE II

	pH	Per Cent Increase in Filtrability
Untreated settlings	...	.....
Limed settlings	...	83.6
Treated settlings at	7.5	139.6
Treated settlings at	6.7	151.1
Treated settlings at	6.3	147.6

The difference in the filtrability between 7.30 pH and 6.7 pH is relatively small. The chief objection to a 7.3 pH of the treated settlings is that the cake does not seem to leave the cloth as free as it does when the pH is 6.8. This, of course, is a very important point which cannot be neglected, because the success of the filter depends upon the ease with which the cake leaves the cloth. When the settlings are acidified to pH values below 6.7, they tend to show a reduction in the filtrability. While this is undesirable, there are objections which are more important than this. First, we have the possibility of inversion of sucrose at lower pH values. Naturally, as the pH is reduced below 6.8 pH, inversion will become a serious factor even at the temperatures and time intervals involved. Then, too, we have found that the phosphates become more soluble at 6.5 pH.

There is a rapid increase in phosphate below this pH. If such a condition existed, the filtrate would have to be returned to the mixed juice and be resettled to avoid scaling in the evaporators and the formation of a precipitate. Reactions below 6.8 pH are to be avoided at all times in the Borden treatment.

The P_2O_5 Content of the Filtrate from "Borden Treated Settlings":

A number of tests were made to determine the pH at which the P_2O_5 content of the filtrate from the Borden treated settlings begins to increase. For if the phosphate increased to any extent at 6.8 pH, then a precipitate would be formed on mixing with the clarified juice of a higher pH. Such a condition would be very undesirable. It would necessitate the returning of all the filtrate to the mixed juice to be resettled. The results have been tabulated below:

TABLE III

Filtrate from "Borden Treated Settlings."

pH	Per Cent P_2O_5
7.5	.005
7.2	.005
7.1	.005
7.0	.005
6.9	.005
6.7	.007
6.6	.007
6.4	.015
6.3	.025
6.0	.035
5.8	.085

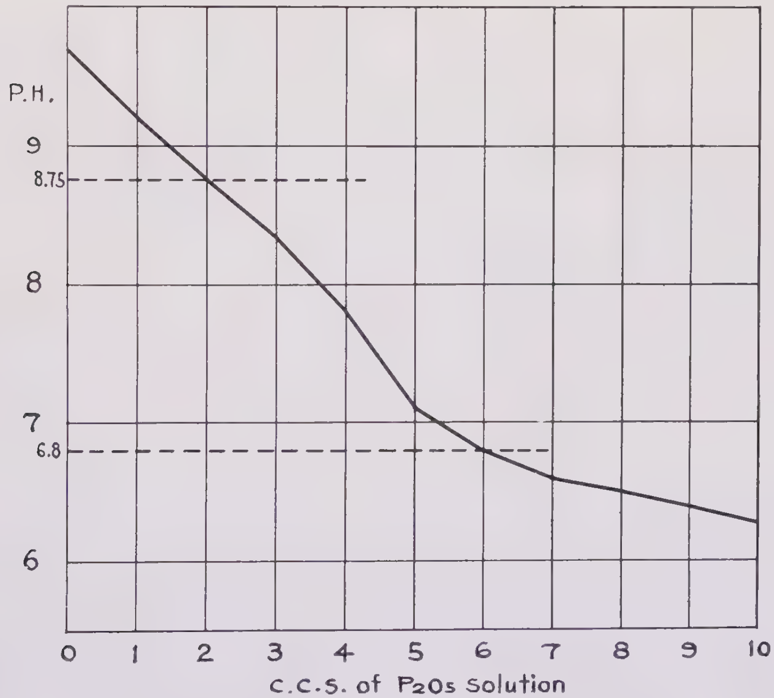
From these data, we can conclude that below 6.6 pH the P_2O_5 content of the filtrate increases quite rapidly. In the Borden treatment, the pH of the settlings is 6.8, so that with careful control no increase in P_2O_5 should be secured. The filtrate can be safely mixed with the clarified juice without forming a precipitate or increasing the scale in the evaporators. These conclusions have been substantiated by actual factory practice. Samples of filtrate which were composited over a long period of time (12 hours) did not show any increase in P_2O_5, showing that the control was maintained within satisfactory limits.

The Titration Curve:

When limed settlings are acidified with a double superphosphate solution, the decrease in pH of the treated settlings will not be proportional to the quantity of the double superphosphate added. Thus, if we take a given quantity of settlings, about 40 c.c. and add c.c. portions of a weak double superphosphate solution to the limed settlings and determine the pH after the addition of each portion of double superphosphate, this will give us a series of pH values and the corresponding c.c. of reagent. Plotting these data on cross section paper and drawing a smooth curve through the points, will give a titration curve. From the shape

of such a curve we can predict whether a 6.8 pH as is desirable in the Borden treatment, can be easily controlled.

Such data as described above were determined on limed settlings and plotted in a graph (Graph 1). The shape of the curve above 7.0 pH is fairly steep. This means that with relatively small quantities of reagent added to the settlings, comparatively large decreases in pH are secured. Below 7.0 pH the curve shows a very pronounced flattening out, which means that considerably smaller changes in pH are secured with the same amount of double superphosphate solution, so that 6.8 pH which is on the flat portion of the curve should be easily maintained with a suitable indicator. When a small excess or deficiency of reagent is added in trying to acidify to 6.8 pH, the pH actually secured will not be far from 6.8.



Graph 1

The following data taken from Graph 1, show the distribution of the double superphosphate when settlings limed to 8.75 pH are acidified to 6.8 pH:

From 8.75 to 8.35 pH requires 25 per cent of the total double superphosphate.
From 8.35 to 7.75 pH requires 25 per cent of the total double superphosphate.
From 7.75 to 7.10 pH requires 25 per cent of the total double superphosphate.
From 7.10 to 6.80 pH requires 25 per cent of the total double superphosphate.

If the settlings are acidified to 6.5 pH, it would require 50 per cent more double superphosphate to reduce the pH from 6.8 to 6.5.

Mechanical Handling of Settlings Before Filtration:

The equipment used in treating all the settlings consists of three tanks placed immediately below the settling tanks. These mud tanks each have a capacity of 350 cubic feet. There is a propeller mounted in each tank revolving at the rate of 40 r.p.m. The propellers are in motion continuously. A small sample line runs from each tank through a pump to the treating station above. Suitable floats are arranged to indicate when a tank is full. A pressure gauge on the pump feed line indicates when the tank is empty. Recording thermometers are mounted on two of the tanks which not only record the temperature of the settlings but also give a count of the number of tanks filled each day.

The treating station consists of two rectangular boxes, the one for the milk of lime, the other for the double superphosphate solution. Each box is fitted with three drains, one leading to each tank.

The double superphosphate solution is prepared in a wooden mixing tank. It is simply made by mixing double superphosphate with water. The solution is kept in continuous motion to prevent the heavy insoluble matter from settling out. With this arrangement the operator limes the settlings to the desired pH and then acidifies with the double superphosphate solution to 6.8 pH.

The treated settlings are pumped through centrifugal pumps to the filters. These treated settlings are sometimes allowed to remain in these tanks for a half hour or more. During this time they are subjected to the constant beating of the propeller, and receive a still further beating when they are pumped by the centrifugal pumps.

The effect of this mechanical handling of the settlings on the filtrability is shown in the following tabulation. The comparison is made between bucket treated settlings and tank treated settlings:

TABLE IV

	Bucket Treated Settlings			Tank Treated Settlings			Per Cent
	pH	Volume of Filtrate	Thickness of Cake	pH	Volume of Filtrate	Thickness of Cake	Decrease in Filtrability
		ccs.			ccs.		
	7.0	1280	5/16"	6.7	940	1/4"	26.5
	6.7	1060	3/16"	6.8	700	1/8"	34.0
	6.7	1550	1/4"	6.8	1000	3/16"	35.5
	6.8	1600	5/16"	6.8	1240	1/4"	22.5
	6.9	1600	1/4"	6.7	1200	3/16"	25.0
	6 8	1700	3/16"	6.9	1140	1/8"	33.0
	7.0	1060	3/16"	6.8	700	1/8"	34.0
	6.7	1250	1/4"	7.1	900	.....	26.0
	7.0	1060	1/4"	6.8	700	1/8"	34.0
	6.8	1050	1/4"	6.9	900	1/4"	14.0
	7.3	1650	3/8"	7.3	950	1/4"	42.0
	6.8	1450	3/8"	7.0	700	3/16"	52.0
Avge.	6.88	1360	1/4"	6.88	925	3/16"	32.0

Under the heading "Bucket Treated Settlings" are the results secured when small portions of the settlings were carefully treated without any violent mixing. These results represent the maximum attainable with the Borden treatment.

Under the heading "Tank Treated Settlings" are the results secured when the settlings have been treated on a large scale with the mechanical equipment originally designed for this purpose. The average of the twelve tests given in the above tabulation shows a reduction in filtrability amounting to 32 per cent. Individual tests vary from 14 per cent to 52 per cent.

In order to determine the cause of this reduction in filtrability a number of tests were carried out. The first point to be investigated was whether this reduction in the filtrability of the tank treated settlings was of a permanent nature or whether after standing for a reasonable length of time the filtrability would be restored to that of the bucket treated settlings:

TABLE V

Treatment	pH	Vol. of Filtrate	Temperature
Bucket treated settlings........	6.8	1080 c.c.	77° C.
After standing ½ hour........	...	1050 c.c.	76° C.
Tank treated settlings..........	7.0	850 c.c.	77° C.
After standing ¼ hour........	6.9	800 c.c.	77° C.
After standing ½ hour........	6.8	800 c.c.	77° C.

The results of another test similar to the one cited above follow:

TABLE VI

Treatment	pH	Vol. of Filtrate	Temperature
Bucket treated settlings........	6.7	950 c.c.	79° C.
After standing ¼ hour........	...	960 c.c.	77° C.
Tank treated settlings..........	6.8	700 c.c.	76° C.
After standing ¼ hour........	...	700 c.c.	73° C.

In the above tests the settlings were stirred only during the treatment. There was no material change in the filtrability either in the bucket or tank treated settlings on standing without agitation. From these tests, we can conclude that this reduction in filtrability of the tank treated settlings is permanent.

In the following series of filtration tests, comparative data were secured between bucket treated settlings, tank treated, and bucket treated settlings which were subjected to rapid stirring during the treatment. Such data were secured for the purpose of finding out what effect rapid stirring had on the filtrability of the treated settlings. The results of five tests are given in the tabulation below:

TABLE VII

	Bucket Treated		Tank Treated			Bucket Treated*		
		Volume of		Volume of	Per Cent		Volume of	Per Cent
	pH	Filtrate	pH	Filtrate	Reduction	pH	Filtrate	Reduction
	6.9	1100 c.c.	7.0	950 c.c.	13.6	6.9	950 c.c.	13.6
	7.2	1200 c.c.	6.9	1000 c.c.	17.0	6.9	1050 c.c.	12.5
	6.8	1150 c.c.	7.0	850 c.c.	26.1	6.8	900 c.c.	22.0
	6.7	850 c.c.	6.8	700 c.c.	17.6	6.8	725 c.c.	14.7
	6.7	1300 c.c.	6.8	975 c.c.	25.0	6.8	1050 c.c.	19.2
Average . . .	6.9	1120 c.c.	6.9	895 c.c.	20.0	6.8	935 c.c.	16.5

There is a reduction in the filtrability of the bucket treated settlings which were subjected to rapid stirring. The average of five tests is 16.5 per cent; this is almost equivalent to the reduction produced in the tank treated seetlings which amounts to 20.0 per cent. From this, we may conclude that the reduction in the filtrability of the tank treated settlings is due to the severe stirring action of the propeller and the beating effect of the centrifugal pumps.

The double superphosphate solution used in acidifying the settlings contained large quantities of insoluble matter which were in a very fine state of division. The following tests were made to determine whether in the absence of this insoluble matter, rapid stirring would still produce this reduction in filtrability. A portion of double superphosphate solution was filtered through filter paper to remove the insoluble matter. Comparative tests were then made simply between bucket treated settlings which were gently mixed, and bucket treated settlings which were violently stirred:

TABLE VIII

Treatment	pH	Volume of Filtrate	Per Cent Reduction
Bucket treated, gentle mixing.........	6.8	1100 c.c.	. . .
Bucket treated, violent mixing.........	6.8	1050 c.c.	4.6
Bucket treated, gentle mixing.........	6.8	1240 c.c.	. . .
Bucket treated, violent mixing.........	6.8	1175 c.c.	5.2

The average reduction for the two tests is 4.9 per cent. In the presence of the insoluble impurities, there was an average reduction of 16.5 per cent as given in Table VII. From these data, the conclusion has been drawn that the reduction in filtrability in the tank treated settlings is due to the stirring action and is greatly increased by the finely divided impurities which are introduced with the double superphosphate solution. The remedy lies in gentle mixing while treating the settlings. As soon as the treatment is completed, the stirring should be stopped.

For these reasons, the settlings which were sent to the Oliver Filter were treated separately in the following manner: A tank having two compartments,

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* These were bucket treated as in column 1, but were subjected to severe stirring during the treatment.

each of 40 cubic feet capacity, was mounted in front of the filter. The unlimed settlings were pumped with a plunger pump from a receiving tank into this small tank. They were then treated in the same way but were mixed by hand. The treated settlings were fed into the filter by gravity. A recording thermometer was mounted on this tank which gave the temperature and also a count of the number of tanks filled. It also gave a record of the actual operating time. While this was a temporary arrangement it clearly demonstrated the conditions which must be met to do the treating on a large scale mechanically. With this change in the mechanical handling of the treatment of the settlings, no further difficulties were encountered by the Oliver Filter.

The Effect of the Temperature on the Rate of Filtration:

A large portion of treated settlings was heated up to 85° C. Filtration tests were made at a series of temperatures as the settlings cooled off. The data are tabulated below:

TABLE IX

Temperature of Settlings When Filtered	Volume of Filtrate c.c.
85 ° C.	750
80 ° C.	750
73.5 ° C.	720
66.0 ° C.	710
61.0 ° C.	700
57.0 ° C.	710
53.0 ° C.	705
49.0 ° C.	675
45.0 ° C.	640

There is a relatively small difference in the volume of filtrate between 85° C. and 53° C. Under 53° C. there is a more pronounced decrease in the volume of the filtrate. From further tests which were made the volume of filtrate does not increase materially when the temperature of the settlings is above 85° C. These tests have been carried to as high as 95° C. The temperature of the settlings in the Oliver is between 85° C. and 90° C. At these temperatures the inversion velocity has been materially reduced so that with the pH of the settlings at 6.8, the inversion of sucrose is negligible. The temperature is below the flash point for the vacuum carried.

The Effect of Varying the Vacuum on the Volume of the Filtrate:

In the standard method of comparing the filtrability of the settlings as developed by Mr. Borden, the direct filtration is carried out at 10″ vacuum, and dried out at 15″ vacuum. A number of tests were made on a large sample of treated settlings at widely varying vacuums, as indicated in the tabulation:

TABLE X

Filtering Vacuum	Drying Vacuum	Volume of Filtrate
10″ (Standard)	15″ (Standard)	1000 c.c.
27″	27″	1000 c.c.
7½″	7½″	940 c.c.
5″	5″	950 c.c.
3½″	3½″	850 c.c.
2″	2″	800 c.c.
5″	10″	900 c.c.
3½″	5″	850 c.c.

There is no increase in the volume of settlings filtered at vacuums above 10 inches. At the lower vacuum there is a gradual falling off amounting to 20 per cent at 2″ vacuum. There was a pronounced difference, however, in the way the cake leaves the cloth. At the high vacuum, the cake stuck to the cloth so that when it was removed the cloth was dirty. With lower vacuums the cake was still wet, yet it was coherent enough so that it left the cloth clean.

The ease with which the cake leaves the cloth is very essential to the successful operation of the filter. While a lower vacuum might reduce the capacity about 5-10 per cent, the cake will be easily discharged and leave a clean filtering surface. Under such conditions a high filtering rate may be secured over a long period of time with less frequent stopping to wash the cloth.

The Effect of Repeating the Filtration of Settlings on the Experimental Unit Without Washing the Cloth After Each Test:

Two buckets of settlings were limed to 8.6 pH and acidified with double superphosphate to 6.8 pH. The regular method of making these tests was followed, that is, the settlings were filtered at 10″ vacuum and dried out at 15″ vacuum. The cake was removed from the cloth and the test repeated on the same settlings without washing the cloth:

First run	1050 c.c. filtrate
Second run	1100 c.c. filtrate
Third run	1080 c.c. filtrate
Fourth run	975 c.c. filtrate
Fifth run	900 c.c. filtrate

After the third test there is a dropping off in volume of the filtrate, showing that the cloth was gradually becoming dirty.

Settlings which had been treated in the regular factory equipment were also tested. These settlings had been subjected to severe stirring and pumping through a centrifugal pump. The same method of procedure was followed as described above. The results follow:

First run	850 c.c. filtrate
Second run	650 c.c. filtrate
Third run	625 c.c. filtrate
Fourth run	350 c.c. filtrate

After the fourth run the cloth was very dirty, so that the fifth run was practically nothing.

A third test was made on settlings which were treated as described in test 1. The method of filtering was modified to the extent that the filtration was carried out at 5″ vacuum and the cake dried out at 5″ vacuum.

First run	800 c.c. filtrate
Second run	750 c.c. filtrate
Third run	700 c.c. filtrate
Fourth run	800 c.c. filtrate
Fifth run	850 c.c. filtrate
Sixth run	800 c.c. filtrate
Seventh run	800 c.c. filtrate
Eighth run	775 c.c. filtrate

Using the regular method of making filtration tests on the settlings in test 3, the volume of the filtrate was 830 c.c.

The results given in test 3 show that with a reduced vacuum on filtration there is a very pronounced tendency for the cloth to remain clean. This is undoubtedly due to the fact that the cake is not deposited on the cloth as firmly as it is at higher vacuums, so that when it is discharged from the cloth it will leave the cloth freely. Test 3, also shows that the volume of filtrate for a given cycle is almost the same whether the vacuum is 5″ or 10″.

The Influence of the Composition of the Suspended Solids in the Borden Treated Settlings on the Weight of Cake Formed:

The object of the following series of experiments was to find out, if possible, what factors determined the weight of cake formed in a given filtering cycle. These tests were made under identical conditions; the only difference being in the character of the settlings filtered. The filtration data together with the analytical data have been arranged in the following tabulation:

TABLE XI

Date of sample	3-10-26	1-29-26	2-29-26	1-26-26	1-29-26	2-9-26	2-3-26	2-24-26
Weight of cake gms.	460	372	348	288	188	195	145	136
Weight of solids in cake gms.	69.4	67.0	60.2	47.7	37.6	35.0	29.0	28.0
Volume of filtrate c.c.	1000	1640	1350	1590	1200	725	1600	900
Thickness of cake, in.	7/16	3/8	5/16	5/16	1/4	3/16	1/8	1/8
Vol. of filtrate/Wt. of cake	2.2	4.4	3.9	5.5	6.4	3.7	11.0	6.6
Suspended solids per cent settlings	5.0	3.3	3.6	2.9	2.6	3.8	1.7	2.6
Fiber per cent settlings	1.81	1.20	1.26	1.01	0.86	1.19	.56	0.68
Nitrogen per cent settlings	....	.071	.069	.062	.054	.069	.033	.048
Ether soluble per cent settlings	0.33	0.38	.46	.29	.29	.44	0.24	0.33
Ash per cent settlings	1.26	.84	.98	.73	.66	1.19	0.45	0.74
Silica per cent settlings	0.20	0.15	.15	.16	.13	.23	.10	.12
P_2O_5 per cent settlings	....	0.15	.19	.13	.12	.20	.09	.12
Ratios								
Ash/Fiber	69.4	69.6	77.4	72.4	76.7	98.7	81.4	108.6
Ether Soluble/Fiber	18.2	31.2	36.6	28.4	34.0	36.6	43.5	49.6
Nitrogen/Fiber	...	5.85	5.41	6.12	6.26	5.71	6.02	7.10
SiO_2/Fiber	11.0	12.5	11.8	16.0	15.5	19.0	17.3	17.5
SiO_2/Ash	15.9	18.0	15.3	22.1	20.1	19.3	21.2	16.1
P_2O_5/Ash	...	17.9	19.5	18.0	18.0	17.0	20.8	16.3

Cake Analysis (Sucrose free dry basis)

Fiber	36.2	36.4	35.3	34.8	33.1	31.7	32.7	26.1
Ether soluble	6.60	11.39	12.9	9.89	11.26	11.6	14.22	12.66
Nitrogen	....	2.15	1.91	2.13	2.08	1.81	1.97	1.84
Ash	25.2	25.27	27.32	25.2	25.4	31.3	26.6	28.34
Silica	4.00	4.55	4.18	5.57	5.13	6.04	5.07	4.56
P_2O_5	....	4.52	5.33	4.51	4.56	5.33	5.64	4.62

Analysis of the Filtrate

pH	6.8	7.2	6.9	6.9	7.2	7.0	7.3	6.5
Brix	14.0	14.4	14.8	13.8	13.8	14.4	15.2	14.4
Ash	...	0.33	....	0.29	0.33	....	0.34	....
Chlorides	...	.047	....	.024	.049	....	.062	....
Sulphates	...	.055	....	.....	.040	....	.048	....

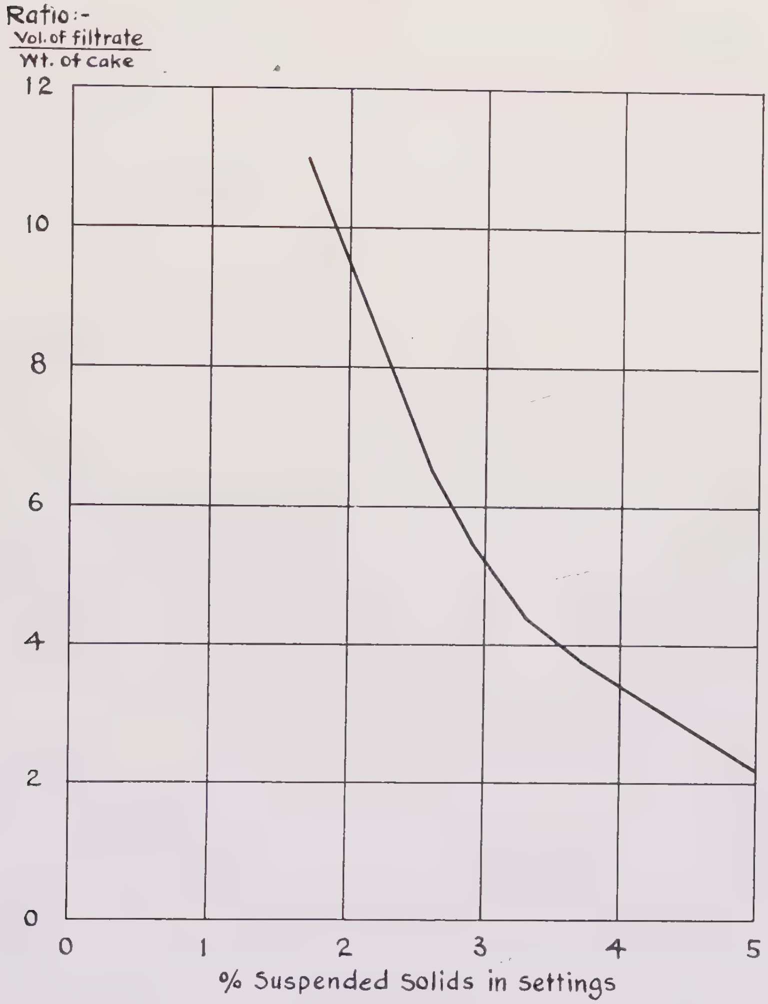
These data have been arranged in the order of the weight of suspended solids in the cake. Comparing the weight of solids in cake for the different samples, we find that there is a wide variation in the amount of cake solids, likewise there is a wide variation between the volume of the filtrate for the different samples. While there is no direct relation between volume of the filtrate and the weight of cake, there is, as might be expected, a definite relation between the ratio of the volume of filtrate to weight of cake and the suspended solids in the settlings. These values have been plotted in Graph 2.

With settlings high in suspended solids, the ratio of the volume of filtrate to the weight of cake decreases. Such a condition would be most favorable to the operation of the Oliver Filter.

The significant data in the table are the relation between per cent fiber in cake and the weight of cake solids. With one exception these figures are very consistent. These data have been tabulated separately as follows:

Grams Cake Solids	Per Cent Fiber in Cake	SiO_2/Fiber
69.4	36.2	11.0
67.0	36.4	12.5
60.2	35.3	11.8
47.7	34.8	16.0
37.6	33.1	15.5
35.0	31.7	19.0
29.0	32.7	17.3
28.0	26.1	17.5

As the per cent fiber in the cake decreases the weight of cake solids formed decreases. For this reason the writer considered the fiber as the filter aid. There is a fairly consistent relation between the silica in the cake and the weight of the cake solids. As the cake solids decrease the SiO_2/Fiber ratio shows a fairly consistent increase. This indicates that some form of silica in the settlings retards the filtration. There are other constituents in the settlings which undoubtedly have an effect on the filtration.



Graph 2

The Effect of the Borden Treatment on the Purity of the Filtrate from the Oliver:

A number of tests were made to compare the purity of the filtrate from the settlings before and after treatment. This would show whether the treatment reduced the purity of the filtrate. The average of eighteen experiments follows:

	Brix	Polarization	Purity
Filtrate from untreated settlings	14.25	12.34	86.72
Filtrate from settlings after treatment	14.16	12.25	86.51

The purity of the filtrate from the treated settlings is 0.21 less than the purity of the filtrate from the settlings before treatment. This difference is considerably smaller than would be encountered in the former practice of liming the settlings before filtration.

In the following series of laboratory tests, the purity of the undiluted filtrate and the purity of the filtrate which included the cake washings were compared. The average of five tests is given in the following tabulation:

	Brix	Polarization	Purity
Filtrate from treated settlings	13.96	12.14	87.00
Filtrate from treated settlings, including cake washings	13.56	11.74	86.60

These figures indicate that an overall decrease in purity will amount to about 0.60 between the clarified juice and the filtrate from the Oliver Filter. This is a smaller decrease in purity than is ordinarily secured in the filter press station.

Routine laboratory samples were taken of the Oliver filtrate over a period of three weeks. Due to the fact that the Oliver filtrate is divided into two portions, the one includes all the washings and a part of the filtrate, the other is filtrate only, made it difficult to secure an accurate sample. A grab sample of both portions of the Oliver filtrate was taken hourly and analyzed every six hours. The purity of this sample was compared with the purity of the clarified juice. Comparison was also made of the purity of the filter press juice with the purity of the clarified juice. The filter press juice sample was a grab sample, taken hourly and composited over a six-hour period. *This sample did not contain any washings.* The following tabulation gives the averages for a three weeks period.

	Clarified Juice	Filter Press Juice*	Oliver Filtrate
Brix	14.83	13.59	12.22
Polarization	12.95	11.83	10.54
Purity	87.32	87.05	86.26
Decrease in purity	.....	—0.27	—1.06

The decrease in purity between clarified juice and filter press juice amounts to —0.27. This agrees very well with the figure —0.21 given on the previous page which was secured with small tests. The purity of the Oliver filtrate is 1.06 less than the purity of the clarified juice. Inspection of the individual figures indicates that the results are influenced to a large extent by the sampling. As explained before, it was impossible to secure a truly representative sample of the Oliver filtrate including the washings, so that this decrease in purity of 1.06 would be materially reduced, as is indicated by the purity of the filtrate including the washings given on the previous page.

The pH Control of the Treatment:

Experiments have shown that the most desirable pH for the Borden treatment of settlings is 6.8. At times, higher pH values will give good results. However, such conditions cannot be anticipated, so that the lower pH is used.

Brom thymol Blue indicator is used to control the reaction of the treated settlings. In alkaline solutions this indicator is blue, while in acid solutions, it becomes light green to yellow. At 6.8 pH Brom thymol Blue is a very distinctive dark green color. So that when limed settlings are acidified, a point will be reached where a drop of Brom thymol Blue indicator added to a small portion of the settlings in a casserole, will turn dark green. The settlings will be close to or at 6.8 pH. This end point is easy to detect.

* This sample does not contain any press washings.

The following tabulation of pH values covers a period of 22 days. Each daily average represents 24 separate samples. Under the headings maximum and minimum are the highest and lowest pH values which were reported by the laboratory for the day. Most of the time the pH of the Oliver filtrate was down to 6.8-6.9 pH. The average of 528 determinations made during 22 days operation is 6.89 pH. The average maximum is 7.21 pH, and the average minimum is 6.61 pH. From the data on the control of the Oliver treated settlings, we can conclude that the method of control is practical.

TABLE XII

	pH of Oliver Filtrate		
Date	Average	Maximum	Minimum
May 18...	7.01	7.3	6.8
19...	7.20	7.8	6.8
20...	6.90	7.5	6.5
21...	7.08	7.5	6.9
22...	6.93	7.4	6.7
25...	6.88	7.22	6.7
26...	6.84	7.1	6.6
27...	6.72	6.9	6.4
28...	6.78	6.9	6.5
29...	6.75	6.9	6.5
31...	6.76	6.9	6.5

	pH of Oliver Filtrate		
Date	Average	Maximum	Minimum
June 1...	6.86	6.90	6.7
2...	6.80	7.0	6.5
3...	6.79	7.00	6.5
4...	6.85	7.00	6.5
5...	6.97	7.6	6.8
7...	7.06	7.5	6.7
8...	6.83	7.2	6.6
9...	6.91	7.5	6.6
10...	6.86	7.0	6.6
11...	6.93	7.4	6.6
12...	6.87	7.2	6.5
Average..	6.89	7.21	6.61

Sulphur Dioxide Treatment of Settlings:

Because of relatively high cost of double superphosphate used in the Borden treatment of settlings, experiments were conducted in which sulphur dioxide gas was used as the acidifying reagent. To warrant the use of such a treatment, the filtration characteristics of the settlings would have to be improved to meet the requirements mentioned in another part of this paper. The results secured by the Borden treatment were used as a basis of comparison in these experiments on sulphuring. The same method of determining the filtrability, described on a previous page, was used.

In the first series of experiments on sulphuring the settlings were first limed to neutrality to phenolphthalein; varying amounts of lime were added to these limed settlings after which the settlings were sulphured back to neutrality to phenolphthalein and to lower pH values.

Experiment 1. Twenty-five grams of hydrated lime were added to 10 liters of settlings which were previously limed to neutrality to phenolphthalein; these settlings were then sulphured back to phenolphthalein neutrality. A filtration test was made on these sulphured settlings as soon as the treatment was completed.

TEST I

Treatment	pH	Volume of Filtrate	Thickness of Cake
Limed settlings	8.5	600 c.c.	3/16″
Borden treated settlings.........	6.8	1425 "	3/8″
Sulphured settlings..............	8.5	1125 "	5/16″

TEST II—Sulphur treatment same as Test I.

Treatment	pH	Volume of Filtrate	Thickness of Cake
Limed settlings	8.5	1225 c.c.	.....
Borden treated settlings.........	6.8	2000 "	1/2″
Sulphured settlings..............	8.5	1885 "	7/16″

In the above two tests which comprise Experiment 1 the sulphur treated settlings show an improvement in the filtration characteristics which is almost equivalent to the Borden treated settlings. The cake from these sulphured settlings did not leave the cloth very clean.

In Experiment 2 the settlings were simply limed to phenolphthalein neutrality and then sulphured back to 6.7 pH without the addition of any extra lime. A filtration test was made as soon as the treatment was completed, and another test on the same settlings which were allowed to stand for twenty minutes.

TEST I—Experiment 2

Treatment	pH	Volume of Filtrate
Limed settlings	8.8	850 c.c.
Borden treated settlings..........	6.8	1300 "
Sulphured settlings...............	6.7	1400 "
After standng 20 minutes.........	6.7	2100 "

TEST II—Experiment 2

Treatment	pH	Volume of Filtrate
Limed settlings	8.8	560 c.c.
Borden treated settlings..........	6.8	1150 "
Sulphured settlings...............	6.7	1175 "
After standing 15 minutes.........	...	1300 "
After standing 30 minutes.........	...	1480 "

The data in the above two tests show that the filtrability of the sulphured settlings is equal to that of the Borden treated settlings and when the sulphured settlings were allowed to stand for twenty minutes to a half hour, a very pronounced improvement was secured. The cake which was formed in these tests on sulphured settlings left the cloth very free. The time which was necessary to secure the maximum benefits from the sulphur treatment was an undesirable feature.

The above two experiments served as a basis for a more extensive series of tests. In the next series a variety of combinations were tried out.

Test I. Settlings limed to neutrality to phenolphthalein and sulphured back to 7.6 pH:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.........	6.7	1500 c.c.	5/16″
Sulphured settlings..............	7.6	1250 "	1/4–5/16″
After standing 20 minutes.......	7.6	1475 "	5/16″
After standing 40 minutes.......	7.6	1475 "	5/16″

In this test, the sulphuring was stopped at 7.6 pH. After standing 20 minutes an appreciable improvement in the filtrability is secured, practically equal to that secured by the Borden treated settlings.

Test II. This test is similar to Test I, with the exception that the settlings were sulphured to 6.6 pH. A portion was filtered immediately after treating, and at half hour and hourly intervals:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.........	6.8	1400 c.c.	5/16″
Sulphured settlings..............	6.6	1350 "	5/16″
After standing ½ hour..........	6.6	1675 "	3/8″
After standing 1 hour...........	6.5	1725 "	3/8″

The test made on sulphured settlings immediately after they were treated showed a filtration rate which was almost equal to that of the Borden treated settlings. Standing shows the same pronounced improvement as in the previous tests. The cake in the tests where the settlings were allowed to stand left the cloth very free.

Test III. Fifteen grams of hydrated lime were added to 10 liters of limed settlings. These settlings were first limed to neutral to phenolphthalein. They were then sulphured to 6.8 pH and tested immediately. Additional tests were made at one-half hour and three-fourth hour intervals:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.........	6.7	1400 c.c.	1/2″
Sulphured settlings..............	6.8	1925 "	3/4″
After standing 30 minutes.......	6.8	2175 "	7/8″
After standing 45 minutes.......	...	2350 "	7/8″

Using this excess lime and sulphuring back to 6.8 pH, produced very free filtering settlings. Even after standing 45 minutes the maximum rate does not seem to have been reached. The cake left the cloth very free. These tests demonstrated that the filtrability of the sulphured settlings was considerably better than that of the Borden treated settlings.

A group of tests similar to those in the preceding experiments were made. Ash analyses were made on the filtrates to find out whether the ash content of these sulphured settlings was materially increased. To ten liters of limed settlings 12 grams of hydrated lime was added. One portion was sulphured back to 8.5 pH, a second portion was sulphured to 7.6 pH, and a third portion was sulphured to 7.0 pH. Samples were taken of the filtrate from untreated settlings and Borden treated settlings.

TABLE XIII

Experiment IV, Test I

Treatment	pH	Volume of Filtrate	Brix	Per Cent Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash Cl. J. Brix	Increase in Ash
Clarified juice...........	7.5	....	11.0	.26	14.0	2.36	.26	...
Filtrate—Borden treated settlings	7.0	1280 c.c.	11.6	.28	12.3	2.41	.26	.00
Filtrate — sulphured settlings	8.5	1250 "	12.65	.37	24.4	2.92	.32	.06
Filtrate — sulphured settlings after ½ hour...	8.5	1450 "	12.35	.38	26.4	3.08	.34	.08
Filtrate — sulphured settlings after ¾ hour...	8.4	1400 "	12.55	.39	26.1	3.11	.34	.08
Filtrate — sulphured settlings after 1 hour....	8.4	....	13.10	.41	23.8	3.13	.34	.08

Test II

Treatment	pH	Volume of Filtrate	Brix	Per Cent Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash Cl. J. Brix	Increase in Ash
Clarified juice...........	7.6	....	11.8	.29	13.2	2.46	.29	...
Filtrate—Borden treated settlings	6.9	1700 c.c.	11.9	.31	12.5	2.60	.31	.02
Filtrate — sulphured settlings	7.6	2100 "	12.8	.37	18.5	2.89	.34	.05
Filtrate — sulphured settlings after ¼ hour...	7.6	2300 "	13.2	.37	18.1	2.80	.33	.04
Filtrate — sulphured settlings after ½ hour...	7.6	2350 "	13.7	.38	16.9	2.77	.33	.04

Test III

Treatment	pH	Volume of Filtrate	Brix	Per Cent Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash Cl. J. Brix	Increase in Ash
Clarified juice...........	7.6	....	14.1	.33	12.66	2.34	.33	..
Filtrate—Borden treated settlings	7.4	1450 c.c.	14.65	.36	14.63	2.46	.35	.02
Filtrate — sulphured settlings	7.0	1885 "	15.7	.45	21.83	2.87	.40	.07
Filtrate — sulphured settlings after 35 min....	7.0	2270 "	16.25	.45	20.71	2.77	.39	.06
Filtrate — sulphured settlings after 1¼ hours..	7.0	2280 "	16.5	.46	19.70	2.79	.39	.06

There is a pronounced improvement in filtrability in the above tests on sulphured settlings. This increases quite consistently as the pH of the treated settlings is reduced. The effect of standing is also very pronounced in Test II and Test III. The explanation for this marked improvement in the filtrability, when the sulphur treated settlings are allowed to stand for some time, may be that the calcium sulphite precipitate becomes more granular on standing, or that the particles which retard filtration require some time to coagulate. There is a

slight reduction in the ash content of the filtrates from the sulphur treated settlings on standing, which may tend to improve the filtrability.

The increase in ash of the filtrate is an undesirable effect, because such an increase in ash would reduce the purity materially. In Test I, the sulphuring was stopped at 8.5 pH. The filtrate from these sulphured tests shows an increase in ash amounting to .06-.08 per cent. In Test II, the pH of the sulphured settlings was 7.6. There was a material reduction in the increase in ash, amounting to almost 50 per cent. With a further reduction in the pH of the sulphured settlings, the ash increases again to .06-.07 per cent increase in ash. These changes in ash are undoubtedly due to changes in solubility of the lime salts which include calcium sulphite, with changes in pH.

This increase in ash in the filtrate from the sulphured settlings combined with the time required to secure the maximum filtrability makes this treatment unsuitable for practical application. Further tests were made with the purpose of modifying the sulphur treatment, which would either eliminate those undesirable features or reduce them to a negligible degree.

In the following tests, settlings were first limed to neutral to phenolphthalein. Varying amounts of lime were then added and sulphured back to approximately 6.8 pH. Filtration tests were made as soon as the treatment was completed and also after the treated settlings were allowed to stand for various time intervals.

TABLE XIV

Test I

Grams Lime Added	Treatment	pH	Vol. of Filtrate ccs.	Thickness of Cake
To 10 liters of settlings 15 gms. $Ca(OH)_2$	Borden treated settlings	6.9	1900	1/2″
	Sulphur treated settlings	6.8	2450	5/8″
	Sulphur treated settlings after ½ hour	6.8	3050	3/4″

Test II

Grams Lime Added	Treatment	pH	Vol. of Filtrate ccs.	Thickness of Cake
10 gms. $Ca(OH)_2$	Borden treated settlings	6.7	1650	1/2″
	Sulphur treated settlings	7.0	2400	3/4″
	Sulphur treated settlings after ½ hour	7.0	2550	7/8″
	Sulphur treated settlings after ¾ hour	7.0	2600	1″

Test III

Grams Lime Added	Treatment	pH	Vol. of Filtrate ccs.	Thickness of Cake
5 gms. $Ca(OH)_2$	Borden treated settlings	6.8	1550	7/16″
	Sulphur treated settlings	6.9	2025	11/16″
	Sulphur treated settlings after ½ hour	6.9	2200	3/4″

Test IV

Grams Lime Added	Treatment	pH	Vol. of Filtrate ccs.	Thickness of Cake
No extra lime added	Borden treated settlings	6.8	1625	1/2″
	Sulphur treated settlings	7.0	1595	1/2″
	Sulphur treated settlings after ½ hour	6.9	1850	5/8″

Test V

No extra lime added	Borden treated settlings	6.9	1580	......
	Sulphur treated settlings	7.2	2140	......
	Sulphur treated settlings after ¼ hour	7.2	2350	......

As the lime was increased in the above group of tests, the filtrability was proportionately increased. The filtrability, however, increased on standing in all cases.

In a preliminary test in which the settlings were first limed to neutral to phenolphthalein, then sulphured back to 6.2 pH and again limed to 7.4 pH, very encouraging results were secured. This treatment was followed in a series of tests, the results of which follow:

TABLE XV

Test I

	pH	Volume of Filtrate
Borden treated settlings	7.1	1700 c.c.
Sulphured settlings	6.6	1675 c.c.
Sulphured settlings limed back to	7.2	2075 c.c.
Sulphured settlings limed and standing ¼ hour	7.2	2125 c.c.

Test II

Borden treated settlings	6.8	1600 c.c.
Sulphured settlings	6.6	1850 c.c.
Sulphured settlings limed back to	7.4	2000 c.c.
Sulphured settlings limed and standing ¼ hour	7.4	2025 c.c.
Sulphured settlings limed and standing ½ hour	7.3	2000 c.c.

Test III

Borden treated settlings	6.8	1340 c.c.
Sulphured settlings	6.2	1850 c.c.
Sulphured settlings limed to	7.0	2400 c.c.
Sulphured settlings limed and standing ¼ hour	7.0	2425 c.c.
Sulphured settlings limed and standing ½ hour	7.0	2400 c.c.

With this modification in the sulphur treatment, the maximum filtrability is secured as soon as the treatment is completed, as shown by the data in the above tabulation. Even after standing one-half hour, there is practically no increase in the volume of filtrate. Such differences as do exist are easily within the experimental differences of the method.

A further test was made to determine the effect that this modified treatment had on the ash content of the filtrate.

TABLE XVI

Treatment	pH	Volume of Fltrate ccs.	Brix	Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash on Cl. J. Brix	Increase in Ash*
Clarified juice	6.5	....	11.65	.28	10.25	2.40	.28	...
Sulphured settlings	6.6	1300	15.44	.43	16.5	2.79	.33	.05
Sulphured settlings limed back to	7.6	1750	16.44	.46	18.5	2.80	.33	.05
Sulphured settlings limed back to	6.9	....	15.19	.43	19.5	2.83	.33	.05

From the results of the above tests, an increase in ash amounting to .05 per cent is secured. This increase in ash will affect the Brix of the filtrate about .1 per cent, resulting in a decrease in purity amounting to about 1.0 per cent on the filter press juice. With the settlings representing about 20 per cent of the mixed juice, an increase of .01 per cent in ash in the evaporator supply juice would be secured. In these experiments, the settlings were usually sulphured at temperatures between 90-100 degrees Centrigrade. While no experiments were carried out to determine the most desirable temperature for conducting the sulphur treatment, there are indications that slightly better results will be secured when the temperature of the settlings is close to 100 degrees Centigrade. Further, at these high temperatures, the solubility of the calcium sulphite is reduced to a minimum. The temperature of the settlings as they are discharged from the settling tanks is usually between 93 and 96 degrees Centigrade. These temperatures are sufficiently high to secure good results and also prevent any flashing in the Oliver Filter. The difference in solubility of calcium sulphite between 90 and 100 degrees Centigrade is very small, so that no further increase in ash beyond that already mentioned should be secured.

The amount of lime and sulphur required was determined by actual titration with known mixtures of milk of lime and a 3 per cent H_2SO_3 solution. The quantity of lime required to raise the pH of the settlings to 8.8 pH is a variable because of the variations in the pH of the settlings as discharged from the settling tanks. In this titration the pH of the original settlings was 6.5, which is abnormally low. The amount of lime required under these particular conditions was 1.05 pounds per ton of settlings; the lime is calculated as CaO. Titrations made in which the sulphur dioxide gas is used as the acidifying reagent, will be fairly regular, that is, the shape of the titration curve will be practically the same in all cases because the buffer action of the P_2O_5 is almost completely removed. It was found that .43 pound of sulphur would be required per ton of settlings. Liming back the sulphured settlings to 7.4 pH requires between .2 and .3 pound per ton of settlings.

Sulphur costs about $40 per ton or 2¢ per pound. Lime costs about $15 per ton or ¾¢ per pound. Using these figures, the estimated cost of the sulphur treatment would be between 3 and 4 cents per ton of sugar. This allows only a 50 per cent recovery of sulphur dioxide gas from the sulphur burned.

In Table XVII, are comparative results typical of the untreated, limed, Borden treated and sulphur treated settlings:

TABLE XVII

	Untreated		Limed		Borden Treated		Sulphur Treated	
	Vol. of Filtrate	Thickness of Cake	Vol. of Filtrate	Thickness of Cake	Vol. of Filtrate	Thickness of Cake	Vol. of Filtrate	Thickness of Cake
	c.c.		c.c.		c.c.		c.c.	
	250	1/8″	850	5/16″	1380	1/2″	1720	5/8″
	550	1/8″	850	3/16″	1600	3/8″	2075	1/2″
	450	....	700	.....	975	....	1350	1/4″
	480	1/8″	950	1/4″	1475	3/8″	1525	3/8″
	...	....	750	3/16″	1650	3/8″	2200	1/2″
	...	....	...	.....	1340	1/4″	2400	9/16″
	...	....	...	.....	1600	3/8″	2650	5/8″
	500	1/8″	1000	1/4″	1350	5/16″	....	.....
	450	1/8″	950	1/4″	1100	5/16″	....	.....
	400	3/16″	940	1/4″	1280	5/16″	....	.....
Average	440	1/8″	874	1/4″	1375	3/8″	1990	9/16″

These data show the pronounced improvement in the filtrability of the settlings produced by the Borden treatment and the sulphur treatment. The filtrate from the untreated settlings and the limed settlings is invariably turbid. The cake is thin and sticky, that is, the cake sticks to the cloth.

The filtrate from the Borden treated settlings and sulphur treated settlings is clear and is usually a lighter color than the filtrate from untreated settlings. The cake is firm and leaves the cloth free. As a rule, the small tests indicate that the cake from sulphur treated settlings leaves the cloth freer and cleaner than the cake from Borden treated settlings. Compared to the filtrability of the untreated settlings liming alone increases the filtrability about 100 per cent, the Borden treatment about 200 per cent and the sulphur treatment about 300 per cent.

In view of the fact that liming settlings to about 8.5-8.8 pH increases the filtrability about 100 per cent, a few tests were made in which the lime was increased beyond these pH limits and filtration tests made. These results are given below:

TABLE XVIII

Treatment	pH	Vol. of Filtrate
Settlings limed to........................	8.5	700 c.c.
Settlings limed to........................	9.6	1100 c.c.
Settlings limed to........................	10.0+	1150 c.c.
Settlings limed to (large excess)..........	...	1350 c.c.
Borden treated settlings..................	6.8	1340 c.c.
Sulphur treated settlings..................	7.3	2400 c.c.

The settlings limed above 8.5 pH showed an improvement in filtrability, but the cake formed in these tests was very sticky. Where a large excess of lime

was used, the filtrability is equivalent to that secured by the Borden treated settlings. The results secured by the sulphur treatment are almost 80 per cent better than the best results secured by liming. The objections to the heavy liming of settlings did not warrant any further tests.

A few filtration tests were made in which varying amounts of Hyflo-supercel were added to limed settlings. The results have been tabulated below:

TABLE XIX

Treatment	Gms. H.S.* Per 10 Liters	Lbs. H.S.* Per Ton Cane	Vol. of Filtrate	Thickness of Cake
Settlings limed to 8.6 pH.......	....	....	950 c.c.	5/16″
Settlings limed to 8.6 pH.......	10 grams	.5 lb.	1080 c.c.	3/8″
Settlings limed to 8.6 pH.......	20 grams	1.0 lb.	1100 c.c.	3/8″
Settlings limed to 8.6 pH.......	35 grams	1.75 lbs.	1200 c.c.	7/16″
Borden treated settlings........	....	....	1550 c.c.	9/16″
Sulphur treated settlings........	....	....	2900 c.c.	1 1/8″

No difference in the appearance of the cake could be observed in these tests with Hyflo-supercel. The increase in filtrability is small, which would mean that large amounts would have to be added. The cost of such a filter aid would be prohibitive, so that no further tests were made.

Strained Settlings:

A group of experiments were made on settlings which were passed through an 80-mesh screen to remove the cush-cush. The filtrability of these strained settlings was compared when subjected to the various treatments. The results appear in Table XX:

TABLE XX

Treatment	Test I Vol. of Filtrate	Test II Vol. of Filtrate	Test III Vol. of Filtrate
Untreated settlings	300 c.c.	325 c.c.	450 c.c.
Limed settlings	650 c.c.	675 c.c.	700 c.c.
Borden treated settlings........	975 c.c.	....	975 c.c.
Sulphur treated settlings.......	1425 c.c.	1650 c.c.	1350 c.c.

There is a reduction in the volume of filtrate in all the tests on strained settlings, yet the proportional differences for the various treatments remain practically the same. The cake formed in these tests shows about the same characteristics as that formed with unstrained settlings, with the exception that in the Borden treated and sulphur treated settlings a cake is formed which is more coherent and can be discharged from the cloth quite readily.

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* H.S. abbreviation for Hyflo-supercel.

The reduction in the volume of filtrate when strained settlings are filtered amounts to about 25-40 per cent. During the year Peck strained settlings were filtered by the Oliver Filter at several different times. Under these conditions the capacity of the filter was reduced by about 25 per cent. The cake on the Oliver seemed to take the wash water. The press station could not handle the Peck strained settlings when the mill was operating at full capacity so that the Oliver could be run only a few hours at a time, which is not long enough to fully test the filter on these settlings.

Part II

The Oliver Filter

Description of the Oliver Filter:

The Oliver Filter, which was installed at the Oahu Sugar Company this past year, is known as a drum type rotary filter. The filter consists of a drum 8 feet in diameter and 12 feet in length, having a filtering area of 300 square feet. This drum rotates on a horizontal axis with the lower portion submerged in a tank containing the settlings. The tank is large enough so that 55 per cent of the surface of the drum can be submerged.

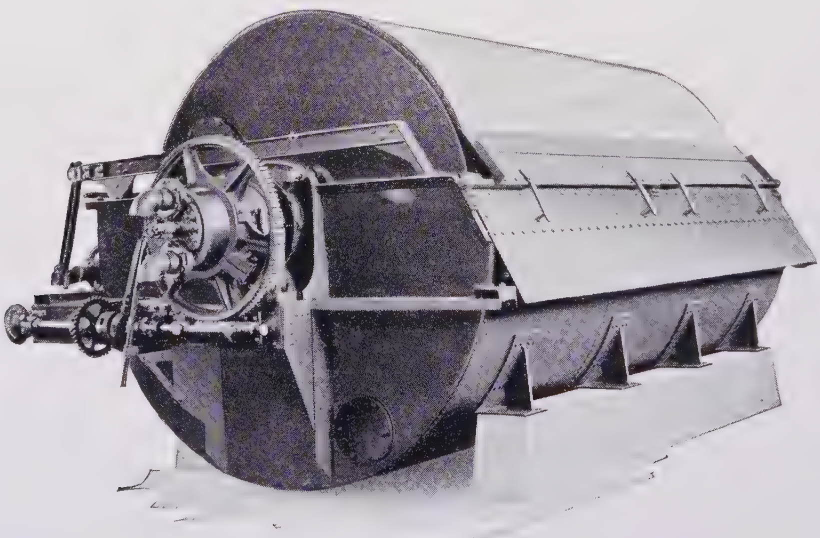

Fig. 1. The Oliver Filter. (Illustration by Oliver Continuous Filter Company.)

The surface of the drum is divided into 24 sections or compartments, the partitions between sections being parallel to the horizontal axis. The dimensions of these sections are 1 foot wide by 12 feet long by 1 inch deep, having a volume of one cubic foot. A perforated screen covers each compartment and supports the filter cloth. The filter cloth covering the drum is held in place by wire winding spaced about one inch apart. Each section is connected by pipes passing through a hollow trunnion to an automatic valve which controls the application of the

vacuum for forming and washing the cake and also for the admission of steam used to discharge the cake. Thus each compartment forms an independent unit, although the filter cloth is attached as a continuous cover over the whole surface of the drum.

An agitator is placed in the bottom of the tank which prevents any separation of the heavier particles, thus insuring an uniform mixture which is necessary to secure an even cake.

A scraper is attached across the tank and rests on the wire winding in such a manner that as the steam blow is admitted to the section, the cloth bulges slightly between the wire winding, lifting the cake which allows the scraper to discharge it. The success of the filter depends entirely on the ease with which the cake leaves the cloth.

Five rows of spray nozzles and one drip pipe are mounted over the top portion of the drum for applying the wash water. As the drum rotates the filtering surface is passed through the settlings in the tank. Immediately, as each compartment under vacuum is immersed, a cake begins to form and continues to form to the point of emergence from the tank. The liquid or filtrate passes through the vacuum pipes to the automatic valve and receiver. The cake is allowed to dry out before the first row of spray nozzles is reached. The amount of wash water to be applied depends upon the thickness of the cake. The time elapsed after the cake emerges from the settlings and when the first wash water is added depends on the character of the cake. After the cake passes under the five rows of spray nozzles and the drip pipe a very thorough washing is secured.

As each section passes out of the washing zone, the vacuum is automatically cut off and the steam blow admitted as this section passes under the scraper which discharges the cake. This leaves a clean surface which passes to immersion and a new cycle. (See Figs. 1 and 2.)

The automatic valve which controls the vacuum is so constructed that the cake is formed at a certain degree of vacuum and is washed at a higher vacuum.

Time of Cycle:

An eight-minute cycle was found to give the best results for all conditions. Thickness of cake, washing time, peripheral speed, and flexibility are the important factors to be considered in deciding upon the optimum time of the cycle.

As the most desirable thickness of cake is ¼″ to ⅜″, with good filtering settlings a shorter time cycle might be used, but with poor filtering settlings, more time is required to form a cake of the desired thickness. There is quite a large variation in the filtering characteristics of settlings.

The washing time is perhaps the most important factor which controls the time of the cycle. The principal object of the Oliver Filter is to recover more sucrose from the cake than is ordinarily recovered in the plate and frame presses. In order to do this, about 200 per cent water on the weight of cake must be applied through the system of spray nozzles. Here again we have the variations in cake to consider. In some types of cake the water can be applied within 25 or 35 seconds after it emerges from the settlings. In other types of cake, a longer

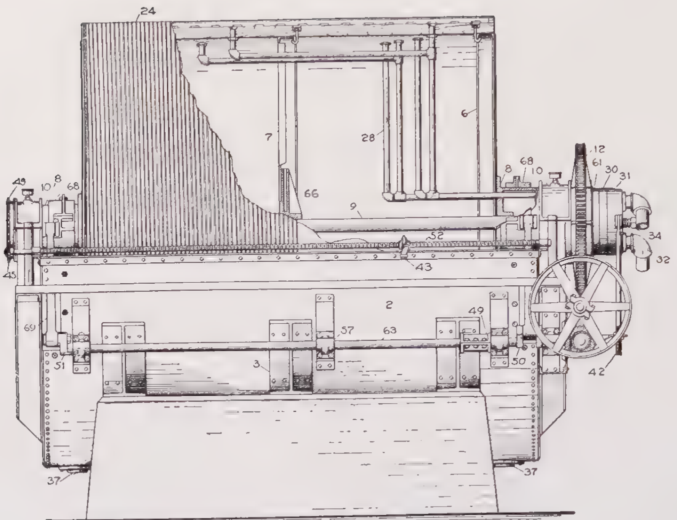

Fig. 2. Showing the essential parts of the Oliver Filter: 1a, Closed steel drum head; 2, Steel filter tank; 3, Tank feet; 6, Drum rims; 7, Drum arms; 8, Drive trunnion; 8a, Rear trunnion; 10, Main bearing (drive end); 10a, Main bearing (rear end; 12, Worm wheel; 18a, Bevel pinion; 24, Wire winding; 28, Vacuum and air pipes; 30, Renewable valve seat; 31, Automatic valve; 32, Vacuum connections; 34, Valve stem; 42, Valve adjusting rod; 42a, Valve adjusting bracket; 43, Wiring carriage; 45, Wiring sprocket; 45a, Feed screw sprocket; 46, Wiring feed screw; 51, Agitator crank; 56, Spur gear; 56a, Ratchet spur gear; 56b, Spur gear flange; 57a, Crankshaft bearing; 61, Valve pipe plate; 62, Drum manhole; 63, Crankshaft; 66, Center spider; 69, Connecting rod; 75, Feed connection; 76, Drain connection; 78, Pinion shaft; 79, Wiring carriage guide; 83, Automatic valve nipple; 85, Agitator crank pin; 88, Stave hook bolt; 89, Ratchet lever. (Illustration by Oliver Continuous Filter Company.)

time must be allowed before applying the wash water. If the wash water is applied too soon the water will cut grooves in the cake; this will result in decreased capacity of the filter, inefficient use of the wash water and a quicker fouling of the cloth. The cake when it first emerges from the tank is very delicate. It must be allowed to dry out before the first row of spray nozzles is reached. The first wash water should be applied before the cake starts to crack. Enough wash water must be applied so that when the cake is discharged, the cloth itself will appear to be wet. The writer believes that when this condition prevails the cloth will remain cleaner for a longer time. Under actual operating conditions, between 5 and 8 gallons of water are applied per minute.

Type of Tank:

The Oliver Filter is equipped with a tank of such a size that 55 per cent of the surface of the drum can be submerged in settlings. For filtering cane settlings the writer believes that a tank of this depth will prove to be the most satisfactory. With the daily and seasonal variations in the characteristics of cane settlings, sufficient leeway must be allowed to take care of all such fluctuating con-

ditions. A tank in which the drum is only 40 per cent submerged could be used at times when settlings of good filtering characteristics are available. With settlings low in the per cent suspended solids and settlings requiring a longer filtering (pick up) cycle, such a tank would prove inadequate. While there is a difference of about $1,000 in the price of the filter with this shallow tank, the writer believes that such a tank would not meet all the conditions encountered during a grinding season. The tank now in use has a total capacity of 160 cubic feet of settlings. This represents about three-fourths of an hour's supply of settlings. If the capacity of the tank can be reduced without changing the per cent of submergence, it would be an advantage.

Blow:

A steam blow is used to loosen and lift the cake as it is discharged from the cloth by the scraper. The blow is admitted into a section as it reaches the scraper and into two sections following the scraper. The pressure of the blow is between 40 and 50 pounds gauge. The main objection to steam blow is that it is hard on the cloth. Certain changes are planned which will tend to lessen this effect.

Both cold air and hot air blow were tried but the results secured were not as satisfactory as the steam. The cloth does not remain clean as long as it does with the steam blow. Mixtures of air and steam were tried without any beneficial results.

Vacuum:

According to tests made on the small test leaf, the cake should be formed at low vacuums. As the vacuum under which the cake is formed is lowered the cake leaves the cloth much freer. With the Oliver Filter in good mechanical condition this seemed to hold true. Of course there is the variation in the character of the settlings to be considered. Actually no definite vacuum can be maintained for all settlings. The important point is that as low a vacuum should always be maintained as will give a cake of the most desirable thickness. In actual operation the vacuum varies from two inches to fifteen inches, depending on the nature of the settlings. If too high a vacuum is carried when the cake is being formed the solid material is drawn into the cloth, making it difficult to wash and discharge.

Usually a higher vacuum is used when the cake is being washed. Although this is not always the case, the vacuum applied to the washing cycle is about 5 inches greater than the vacuum on the pick-up cycle. When high vacuums are maintained on the filtering cycle, then there is only a small difference between the vacuums.

Filter Cloth:

Two types of cloth, plain weave and twill weave, were used on the Oliver Filter. The plain weave or 10 oz. duck was used at a time when the filter was not in good mechanical condition. It was thought that this cloth, because of its

relatively smooth surface, would allow the cake to loosen and leave it free. The cloth did not have the mechanical strength to withstand the force of the steam blow. Heavier weights in this cloth would undoubtedly prove too closely woven for the purpose.

A 15 oz. twill, designated by the manufacturer as 1530 Hooperwood Twill, was used during all but one week of the two months continuous run of the Oliver Filter. This cloth is a more open weave than the duck. One cover made of this cloth was in use about five weeks altogether. A second cover of the same cloth was in use three weeks. At the end of this time, it had to be replaced. Under average conditions, a cover made of this cloth will last about four weeks.

The 18 oz. twill, which was used during the last week of run, was in the writer's opinion too heavy for this work. The heavier weight would give the cloth greater mechanical strength, but it seemed to the writer that the cloth became dirty quicker and required more frequent scrubbing than the 15 oz. twill. The settlings handled during this week contained more soil than ordinarily, due to the rainy weather, but the lighter weight twill was used for a few days on the same type of settlings without giving any trouble. In the writer's opinion the lighter cloth will prove more satisfactory under all conditons.

Washing the Oliver Filter Cloth:

The Oliver Filter cloth should be scrubbed every eight hours. During the past year the filter ran for 22 hours at a time without scrubbing, but as a rule, it was washed every twelve hours. It is the opinion of Mr. Borden, of the Oliver Continuous Filter Company, that more frequent scrubbing will result in increased capacity and will facilitate the washing of the cake materially. With a factory fully equipped with Olivers, a constant total filtering surface could be in operation at all times, that is, as one filter is cut out to wash the cloth, a clean one can be cut in. It has been estimated that six filters would handle the settlings at the Oahu Sugar Company under all conditions and that four filters would filter the settlings during the greater part of the time.

Some attempts were made during the year to devise a method of cleaning the cloth without draining the settlings in the tank back into the mud tanks. But so far these have been unsuccessful. The method of washing the cloth follows:

The settlings remaining in the tank are drained into the mud tank. This drain valve is then closed and the drain to the sewer is opened. Both vacuum lines are closed tight so that there is no vacuum in any of the sections. A hot water wash line is turned on, removing any surplus cake. When the cake is removed a gang of men scrub the cloth with fibre brushes. Compressed air is admitted into the sections. This seems to loosen and dislodge small particles which accumulate in the cloth. After the cloth is thoroughly scrubbed, a weak acid solution is applied to the cloth. This removes any material which remains in the cloth. The acid treatment need only be applied once a day. The cover is then washed with hot water until the washings show no trace of acid. They can be tested with an indicator. All these washings are run into the sewer.

TABLE XXI

		3 days ending April 24, 1926	Week ending May 1, 1926	Week ending May 8, 1926	Week ending May 15, 1926	Week ending May 22, 1926	5 days ending May 29, 1926	Week ending June 5, 1926	Week ending June 12, 1926	Week ending June 19, 1926	Period April 22, to June 19, inclusive
1	Tons cane	9586.	15798.	16828.	17858.	17509.	15120.	16328.	14481.	16068.	142576.
2	Tons sugar	1295.	2511.	2227.	2314.	2320.	2045.	2227.	1953.	2114.	19006.
3	Per cent P_2O_5 in Crusher Juice	.017	.018	.026	.022	.023	.028	.020	.016	[illegible]	.022
4	Tons settlings per day	664.	616.	679.	695.	743.8	767.1	620.	518.	[illegible]	[illegible]
5	Settlings % Mixed Juice	18.5	17.6	20.8	20.6	22.8	22.2	20.5	20.15	21.77	[illegible]
6	Tons cane per ton of settlings	4.81	5.09	4.13	4.29	4.10	3.94	4.39	4.65	[illegible]	[illegible]
7	Tons settlings filtered by Oliver per day	158.7	168.4	178.	175.6	153.0	174.9	154.2	144.5	[illegible]	[illegible]
8	Tons settlings filtered by Oliver per hour	7.21	7.66	8.10	7.98	7.39	7.95	7.21	7.05	[illegible]	[illegible]
9	Tons settlings filtered by Oliver per week	476.0	1010.4	1068.	1053.0	918.0	874.5	925.2	867.0	895.8	970.6
10	Tons cane equivalent to tons settlings filtered by Oliver per hour	34.5	39.0	33.45	34.15	30.3	31.3	31.65	32.85	30.16	32.56
10a	filtered by Oliver per day	763.35	858.0	736.	751.	627.2	689.0	677.3	673.4	621.3	700.0
11	Hour filtering per day	22	22	22	22	20.7	22	21.4	[illegible]	20.6	[illegible]
12	Hour filtering per week	66	132	132	132	124	109.5	128.5	[illegible]	[illegible]	[illegible]
13	Gallons settlings per sq. ft. per hour	5.50	5.88	6.20	6.10	5.7	6.1	[illegible]	5.41	[illegible]	5.79
14	Settlings filtered by Oliver % total settlings	23.9	27.4	26.2	25.25	21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	Suspended solids % settlings (calculated)	2.5	2.9	2.05	[illegible]	[illegible]	1.96	2.0	2.4	[illegible]	[illegible]
16	Thickness of cake (calculated)	1/4"	5/16"	1/4"	1/4"	[illegible]	3/16"	5/32"	[illegible]	[illegible]	[illegible]
17	Tons cake from Oliver per hour (calculated)	1.20	1.42	[illegible]	1.20	[illegible]	0.98	0.91	[illegible]	[illegible]	[illegible]
18	Tons cake from Oliver per day (calculated)	26.5	31.2	25.1	26.5	20.2	21.4	19.5	18.5	[illegible]	[illegible]
19	Tons cake from Oliver per week (calculated)	79.2	187.4	152.4	159.0	121.2	107.0	117.0	111.0	[illegible]	[illegible]
20	Tons cake from Oliver equivalent to ton of press cake from old presses	1.47	1.50	1.50	1.66	1.52	1.39	[illegible]	0.77	1.27	[illegible]
21	Polarization % cake from Oliver	0.97	1.31	1.25	1.02	1.17	0.84	1.18	[illegible]	[illegible]	1.14
22	Moisture % cake from Oliver	82.7	84.1	84.20	84.8	82.71	83.4	[illegible]	81.47	[illegible]	[illegible]
23	Tons polarization in Oliver cake per week	0.77	2.45	1.91	1.62	1.42	0.90	[illegible]	[illegible]	[illegible]	[illegible]
24	Polarization % press cake from old presses	4.4	4.53	4.16	3.50	[illegible]	5.61	4.87	[illegible]	[illegible]	[illegible]
25	Moisture % press cake from old presses	71.6	71.9	74.6	72.0	71.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	Tons press cake equivalent to tons cake from Oliver per week	54.0	124.5	101.4	96.0	79.5	77.0	85.0	114.0	[illegible]	[illegible]
27	Tons polarization in press cake	2.28	5.64	4.22	[illegible]	[illegible]	[illegible]	4.14	6.10	[illegible]	[illegible]
28	Tons polarization saved by Oliver per week	1.61	3.19	2.31	1.74	[illegible]	[illegible]	2.76	4.80	[illegible]	[illegible]
29	Estimated saving of total tons polarization by Oliver on all settlings per week	6.74	11.64	8.82	[illegible]	[illegible]	11.80	[illegible]	[illegible]	[illegible]	[illegible]
30	Tons polarization available per week	6.20	10.71	8.31	[illegible]	9.70	10.86	10.16	[illegible]	15.50	11.10
31	Pol. in cake from Oliver per 100 cane	[illegible]	.048	.043	.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	Pol. in cake from presses per 100 cane	[illegible]	0.11	.096	[illegible]	.097	.125	.101	[illegible]	[illegible]	[illegible]
33	Tons double superphosphate per week for settlings filtered by Oliver	1.96	2.25	2.00	[illegible]	1.69	1.81	1.94	[illegible]	[illegible]	[illegible]
34	Tons settlings per ton of double superphos.	159	[illegible]	[illegible]	[illegible]	543.	483.0	477	[illegible]	[illegible]	[illegible]
35	Tons double superphosphate per week for all the settlings	4.14	8.21	7.63	[illegible]	7.86	7.94	[illegible]	8.28	9.70	8.31
36	Total cost of double superphosphate per week at $56.80 per ton	$ 252.19	466.33	[illegible]	[illegible]	446.45	[illegible]	440.77	470.31	550.96	[illegible]
37	Cost of double superphosphate per ton of sugar	$ 0.195	0.179	[illegible]	[illegible]	0.192	[illegible]	0.198	0.241	0.26	[illegible]

Operating Data of the Oliver Filter:

The Oliver Filter was put into regular operation on April 22 and ran continuously until the end of the crop, June 22, 1926, stopping only for washing the cloth or when the mill was shut down. Previous to this time considerable difficulty was experienced due to a mechanical defect in the filter itself and to the mechanical handling of the settlings. All the settlings which were filtered by the Oliver Filter were treated in a small mixing tank divided into two compartments, each having a volume of 40 cubic feet. The lime and double superphosphate were added and gently stirred with a paddle, by hand. The treated settlings were run into the Oliver Filter by gravity. A count of the tanks was kept so that the volume of settlings filtered each day was known.

Table XXI, which follows, gives the operating results for each week and for the period.

Discussion of the Operating Data Given in the Above Tabulation:

Item 3. Per Cent P_2O_5 in Crusher Juice: The variations in the phosphoric acid content of the crusher juice are relatively small. However, for conditions which prevail at the Oahu Sugar Company, Ltd., they are normal, that is, none of their juices are very high in P_2O_5 so that these variations are as large as might be expected at any time. The relation between the settlings per cent mixed juice and the P_2O_5 in crusher juice is fairly consistent. As the P_2O_5 increases, the volume of the settlings increases. This would be more pronounced if the liming of the mixed juice were constant, but the pH of the limed mixed juice was reduced in the "so-called" high phosphate juices. This reduced the volume of the settlings.

Item 4. Tons Settlings per Day: From the number of mud tanks filled each day, the tons settlings were calculated. This figure is necessary in order to accurately estimate the number of filters required to meet all the conditions encountered during the year.

Item 5. Settling Per Cent Mixed Juice: Tons settlings per day divided by tons mixed juice per day gives settlings per cent mixed juice. While the average figures for the weeks do not show a wide variation in the settlings per cent mixed juice, daily figures show a wider variation. The minimum figure per day during this period is 16.2 per cent and the maximum is 28.3 per cent settlings.

Item 6. Tons Cane per Ton of Settlings: Dividing the tons cane per day by the tons settlings gives the tons cane per ton settlings. There is a fairly consistent relation between the tons cane per ton of settlings and the P_2O_5 in crusher juice. As the P_2O_5 in crusher juice increased, the tons cane per ton of settlings decreased.

Item 7. Tons Settlings Filtered by the Oliver Filter per Day: The settlings filtered by the Oliver Filter were measured. From this, the tons settlings were calculated. The average daily capacity of the Oliver Filter for the first seven weeks is fairly constant. Due to irregular grinding during the last two weeks this figure is somewhat lower.

Item 8. Tons Settlings Filtered by the Oliver per Hour: Dividing the tons settlings filtered per day by the hours actual filtering time gives the tons settlings filtered per hour. The actual filtering time is used in this calculation rather than the total operating time, which would include the time required for washing the filter. If a factory is completely equipped with Oliver Filters, when one filter is shut down to be washed a clean filter is put into service without any reduction in the total filtering surface in use.

These figures show that the capacity of the Oliver is fairly constant, there being only one ton difference between the maximum and minimum tons settlings filtered by the Oliver per hour.

Item 10. Tons Cane Equivalent to Tons Settlings Filtered by the Oliver per Hour and per Day: The average for the period shows that the Oliver filtered the settlings from 32.56 tons cane per hour or 700 tons cane per day.

Item 11. Hours Filtering per Day: For the first four weeks, this is estimated at 22 hours per day. For the remainder of the period, the actual filtering time was recorded.

Item 13. Gallons of Settlings per Square Foot per Hour: This figure is given simply for comparative purposes. The average figures for the individual weeks are fairly constant.

Item 14. Settlings Filtered by the Oliver Per Cent Total Settlings: From items 7 and 8 it is seen that the capacity of the Oliver Filter is fairly constant. With variations in the grinding rate and variations in the volume of settlings per cent mixed juice, it is quite natural to expect large variations in item 14. However, it indicates the number of filters which would be required to meet all the varying conditions. The figures given may be too low by a few per cent; nevertheless, they are comparative. The settlings filtered by the Oliver Filter are accurately measured, while the settlings filtered in the presses are calculated from the number of mud tanks filled each day. It is possible that at times these tanks were not entirely emptied because of lack of tank capacity. On the other hand, we assumed that the tanks were filled always to within six inches of the top allowing 325 cubic feet of mud per tank with an actual capacity of 350 cubic feet. For this reason, the writer did not make any corrections in the volume of settlings filtered in the presses.

Item 15. Suspended Solids Per Cent Settlings: This figure was calculated from the cake solids and the volume of settlings filtered. Although the weekly averages are fairly uniform there is considerable fluctuation during the day. The suspended solids in the settlings have been as high as 5.0-6.0 per cent.

Item 16. Thickness of Cake: The average thickness of cake for the Oliver Filter was calculated from the weight of cake per hour, the average for the run being 7/32″. To secure the best results the cake should be at least 3/16″ and not greater than 3/8″. When the cake is too thin, it becomes less coherent with the result that when it is discharged, it will not leave the cloth clean. If the cake is too thick, the amount of wash water which must be applied to reduce the polarization of the cake to less than 1.0 per cent cannot be added in the time available.

Item 17. Tons Cake from the Oliver per Hour: With the exception of one week, the cake discharged from the Oliver Filter per hour is fairly uniform. The average for the run was 1.09 tons per hour; this is equivalent to 0.78 ton press cake per hour.

Item 20. Tons Cake from the Oliver Filter Equivalent to Cake from Presses: Due to the difference in moisture content and polarization, 1.40 tons of Oliver cake is equivalent to 1.0 ton cake from presses. With the exception of one week this ratio is fairly uniform. This factor must be applied to the polarization and the weight of cake from the Oliver Filter, to reduce these figures to an equivalent basis with the filter press data.

Item 21. Polarization Per Cent Cake from Oliver: The average for the run was 1.14. With more experience in the operation of the filter and the application of the wash water, it is possible to reduce this polarization materially. There were a few times when it seemed impossible to reduce the polarization of the cake to a lower figure. With a constant pressure on the wash water line and with wash water free from cush-cush particles which clogged the nozzles, the washing of the cake should be facilitated. A polarization of 1.14 per cent on Oliver cake is equivalent to 1.6 per cent polarization on filter press cake.

Item 22. Moisture Per Cent Cake: The per cent moisture in cake cannot be reduced below this point. As the cake dries out, a point is reached where the cake begins to crack; further drying out is impossible. Due to the varying composition of the cake, the per cent moisture will vary a few per cent as is indicated by the weekly averages.

Item 34. Tons Settlings per Ton of Double Superphosphate: This figure is the actual amount of settlings treated at the Oliver Filter per ton of double superphosphate. Two tests which were made by Mr. Borden and the writer, indicate that the tons settlings per ton of double superphosphate can be materially increased. In one test, 1,360 cubic feet of settlings were treated with one bag of double superphosphate; in the second test 1,120 cubic feet were treated with one bag of acid. The average of these two tests is 1,240 cubic feet per bag of double superphosphate or 41.3 tons settlings per bag of double superphosphate. This amounts to 660 tons settlings per ton of double superphosphate. With more experience, the operator should be able to approach this figure.

Item 37. The Cost of Double Superphosphate per Ton of Sugar: The average for the period is 20.8 cents per ton of sugar. The weekly figures vary considerably. On the basis of data mentioned above, the cost of the double superphosphate is 15 cents per ton of sugar.

Statement of Estimated Savings and Costs:

In estimating the total saving which might be secured by filtering all the settlings with Oliver Filters, it has been assumed that six Olivers having a filtering surface of 300 square feet each, would be required. Five filters would handle all the settlings during the greater part of the time. However, at certain times, such as the first six weeks of the crop, six filters would be required. The

settlings which were secured at this time of the year did not respond to the Borden treatment to the same extent that they did later in the year.

A comparative statement of operating costs of the Oliver Filter and the filter presses, also the estimated savings due to the Oliver Filters has been itemized in the following tabulation:

	Oliver Filter	Filter Presses
Double superphosphate, per ton of sugar	20.8 cents	10.0 cents
Labor, per ton of sugar	3.5 cents	5.6 cents
Filter cloth, per ton of sugar	0.8 cents	7.5 cents
Acid for cleaning cloth, per ton of sugar	0.3 cents	....
Oliver wire, per ton of sugar	0.3 cents	....
Total operating expenses, per ton of sugar	25.7 cents	23.1 cents
Value of sugar lost in cake, per ton of sugar	19.7 cents	57.0 cents
Total cost, per ton of sugar	45.4 cents	80.1 cents
Less the fertilizer value of the double superphosphate recovered in the press cake, per ton of sugar	19.1 cents	9.2 cents
Net cost, per ton of sugar	26.3 cents	70.9 cents
Estimated saving made by Oliver Filters, per ton of sugar	44.6 cents	

For a crop of 62,500 tons of sugar—$27,875.00.

The above statement applies to conditions which prevail at the Oahu Sugar Company, Ltd.

In the above tabulation, the cost of treating the settlings filtered by the filter presses is 10 cents per ton of sugar, while the cost of treating the settlings filtered by the Oliver filter is 20.8 cents. There are two reasons for this difference in cost. One is that the treatment given the settlings filtered by the presses was purposely reduced, that is, the settlings were limed to a lower pH than the Borden treatment requires. The full benefits of the Borden treatment will not be secured, however, under these conditions. The second reason is that the settlings filtered by the Oliver Filter were overlimed before the addition of the double superphosphate. This, naturally, requires more of this reagent. With a more careful and experienced operator, the quantity of the double superphosphate should be reduced with a material reduction in cost.

It seems to be legitimate to include the cost of the double superphosphate used in treating the settlings filtered by the filter presses as an operating expense for several reasons. The average grinding rate for the 1926 crop was 2,820 tons of cane per day. For 1925 crop it was 2,490 tons of cane per day. For the 1925 crop there were 12 presses with a total of 8,000 square feet of filtering surface available. For five months of the 1926 crop, there were only 10 presses with a total of 6,700 square feet filtering surface available, with the addition of

the Oliver Filter during the last two months. It is very unlikely that the higher grinding rate could have been maintained without treating the settlings. So that any savings which result with the increased grinding rate should be credited to the treatment of the settlings.

The benefits which were secured by treating the settlings are as follows:

First, there was an improvement in the filtrability of the settlings resulting in a shorter filling cycle of the presses. For the 1925 crop, each press discharged an average of 4 tons of cake per day; for the first 5 months of the 1926 crop each press discharged 6.6 tons per day, an increase of over 50 per cent.

Second, the filtrate or filter press juice was sent directly to the evaporator supply tank. This reduced the load on the settling tanks by 20 per cent, because in former years the filter press juice was returned to the mixed juice. This is generally the practice where the settlings are limed heavily before filtration. By reducing the load on the settling tanks, ample settling time was available with this increased grinding rate so that the mixed juice could be limed to its optimum reaction during the greater part of the time.

If the capacities of the settling tanks and filter presses were such that the settlings could be filtered without treatment, regardless of the grinding rate then the treatment would be unnecessary.

Filter Cloths:

The estimated cost of filter cloth for six Olivers for a whole crop was calculated in the following manner: One filter was operated for two months with the cost of filter cloth amounting to $40. During this time, this filter averaged 24.8 per cent of the total settlings. All the settlings could have been filtered with cloth costing $161.30. Nineteen thousand and six tons of sugar were manufactured during this period, so that the cost per ton of sugar is 0.8 cent. The average cost of filter cloth for the filter presses has been estimated at 7.5 cents per ton of sugar. The writer believes that this is a conservative estimate representative of Hawaiian practice. On such a basis, an installation of Oliver Filters would effect a saving of 6.8 cents per ton of sugar.

With the filter in continuous operation one cover was used for five weeks, the second cover was used for three weeks, or an average of four weeks per cover. With a battery of six Oliver Filters, where each filter would be operating only a part of the time, one cover would last for over five weeks. In making this calculation, it is assumed that the only wear on the cloth is while the filter is in actual operation. The life of a cover will probably be lengthened by making some mechanical improvements which will protect the cloth from the steam.

Labor:

It has been assumed that the labor requirements per shift to operate six Oliver Filters would be as follows: one man to treat the settlings, two men to operate the filters and one man to wash the filters. With the wage scale which prevails at the Oahu Sugar Company, Ltd., this would amount to 3.5 cents per ton of

sugar. The labor cost to operate the filter presses is estimated at 5.6 cents per ton of sugar. Using a battery of Oliver Filters would effect an estimated saving of 2.4 cents per ton of sugar.

Acid Used for Cleaning the Oliver Filter Cloth:

A weak solution of muriatic acid is used to clean the Oliver Filter cloth once a day (24 hours). This amounts to about 1.5 gallons of acid per day per filter. On such a basis, approximately 50 carboys (120 pounds each) would be required. The cost per carboy is $3.25 or $162.50 per crop. This is equivalent to 0.26 cent per ton of sugar.

Oliver Wire:

Using No. 14 hard galvanized wire of .08″ diameter, with 1″ spacing on the drum, the covering of one Oliver Filter will require 3,900 feet, or 26 coverings will require about 102,000 feet, or 1,760 pounds. Stocking six reels of 20,000 feet each at $29.65 per reel amounts to $178 per crop. This is equivalent to 0.3 cent per ton of sugar. These figures have been taken from Mr. Borden's report (page 29).

Value of Sugar-Lost:

Under the existing conditions at the Oahu Sugar Company, where the grinding rate has been greatly increased without a proportionate increase in the filter press station, it has been possible to effect a large saving in the polarization in the press cake. As shown in the tabulation the value of the sugar lost in the presses is 57 cents per ton of sugar, while that lost in the Oliver Filter is only 19.7 cents per ton of sugar, amounting to 37.3 cents per ton of sugar. It was assumed that 92 per cent of the sucrose lost in the cake was available. The market value was calculated as 97.5 per cent sucrose, at $82.40 per ton less 10 per cent.

Fertilizer Value of Double Superphosphate Recovered in the Press Cake:

When the Borden treatment of the settlings is carefully controlled, then we can expect to recover all the double superphosphate in the press cake. This will be in the form of a calcium phosphate salt, but in a very finely divided condition. The cake from the Oliver Filter contains about .5-.6 per cent more P_2O_5 than ordinary press cake. The availability of the phosphate has been tested on four samples of cake submitted to the chemistry department for analysis. The following tabulation gives the results of their analyses:

	P_2O_5 Per Cent Cake		
	Total	Available	Per Cent Available
Cake from treated settlings.........	0.958	0.890	92.90
Cake from treated settlings.........	0.940	0.860	91.50
Cake from treated settlings.........	1.276	1.166	91.40
Cake from untreated settlings.......	0.475	0.415	87.40
Average cake from treated settlings	1.058	.972	91.9

From these analyses it is evident that the fertilizer value of the press cake will be increased by an amount equal to 91.9 per cent of the total cost of the double superphosphate.

The total cost of distributing and spreading the Oliver cake for a crop will be increased by about 40 per cent. This is due to the fact that 1.4 tons of Oliver cake is equivalent to 1 ton of press cake. This increase in cost of distributing and spreading the press cake should be charged against the fertilizer value of the press cake.

Whether the total cost of the double superphosphate should be charged against the Borden treatment depends largely on the particular conditions prevailing at a plantation. When the soil requires phosphate application, the phosphate in the press cake should prove just as effective as the phosphate in fertilizer. This is the opinion expressed by the agricultural department of this Station. Under such conditions, the writer believes that it is logical to allow the fertilizer value as calculated, less the increased cost of distribution.

The estimated saving made by the Oliver Filter per ton of sugar as explained in the discussion is 44.6 cents per ton of sugar. For a crop of 62,500 tons of sugar this amounts to $27,875. If, on the contrary, we assume that the settlings could have been filtered in the presses without any treatment and still maintain the same grinding rate and further, if the total cost of the double superphosphate is charged against the Borden treatment, this would reduce the estimated saving to 24.7 cents per ton of sugar, amounting to $15,437.50 for a crop of 62,500 tons of sugar.

The power required to operate six Olivers is small, amounting to about 35-40 horsepower. This includes the power to run a vacuum pump of suitable capacity for an installation of this size. The steam used in discharging the cake is also negligible. These items are compensated for by a similar power requirement to operate the pumps which pump the settlings and water into the presses at fairly high pressures. Using less wash water on the weight of cake will also result in a saving of fuel because there will be less dilution of the filtrate with the result that less water will have to be evaporated. Interest on the investment, depreciation, upkeep and repairs, cannot be accurately estimated for an installation of Oliver Filters. It is quite possible that they will be somewhat less than similar charges for a new installation of filter presses.

The preceding comparative statement of estimated costs and savings between the Oliver Filters and filter presses is based on the conditions which exist at the Oahu Sugar Company, Ltd. The high polarization in the press cake is due largely to a lack of filter press capacity. For a factory of this size there should be about 15,000 square feet of filtering surface available. This factory had only 6,700 square feet of filtering surface available in the filter presses this past year. During the two months of the Oliver run, slightly over 75 per cent of the settlings were filtered by these ten presses.

If there were sufficient filter press capacity which would approximate Hawaiian standards, then it is reasonable to assume that the polarization of the press cake

could be reduced to 2.28 per cent. This is the average for all the factories for 1925. The moisture in cake is assumed to be 71.0 per cent. Using these figures in a similar statement as the preceding one, we then have as follows:

	Oliver Filters	Filter Presses
Total operating expense, per ton sugar	25.7 cents	13.1 cents
Value of sugar lost in cake, per ton sugar	19.7 cents	22.6 cents
Total cost, per ton sugar	45.4 cents	35.7 cents
Less the fertilizer value of the double superphosphate recovered in the press cake, per ton sugar	19.1 cents	....
Net cost, per ton sugar	26.3 cents	35.7 cents
Saving made by the Oliver Filters, per ton of sugar	9.4 cents	

This would amount to a saving of $5,875 for a crop of 62,500 tons of sugar. If the process had to pay for the double superphosphate, then it would cost 9.7 cents more per ton of sugar to operate Oliver Filters than a battery of filter presses.

Advantages of the Oliver Filter:

A low polarization in Oliver cake can be secured.

The amount of wash water is between 200-250 per cent on the weight of cake, thus the dilution of the filtrate is small. The cake is formed on the filter, washed and discharged in an eight-minute cycle, eliminating inversion losses which frequently occur in plate and frame presses. Although the reaction of the settlings is at 6.8 pH, the temperature is considerably reduced so that the inversion while the settlings are in process about one hour, is practically negligible.

With the exception of washing the filter once every 8-12 hours no manual labor is required. The saving in labor cost has been estimated to be 40 per cent.

Using the Oliver Filters will reduce the filter cloth cost by about 90 per cent.

The filtrate is clear and sent directly to the evaporators. The purity of the filtrate is about 1.0 per cent less than the purity of the clarified juice.

Disadvantages:

The cost of the double superphosphate per ton of sugar is 20.8 cents. If the process must pay for this acid by recovering the sucrose in the cake, it can only do so when the polarization is abnormally high. Such a condition exists at Oahu Sugar Company, Ltd., but this is due to a lack of filter press capacity.

The successful operation of the Oliver Filter will require close supervision *all the time.* Carelessness in the treatment of the settlings can result in a complete stopping of the filtration. The application of the wash water must be closely watched, otherwise harmful effects which will result in reduced capacity will be secured. Wash water free from suspended solids at a constant pressure will undoubtedly eliminate some of the troubles encountered this year, but with

varying thicknesses of cake such as frequently occur, careful supervision is essential.

A summary of filtering rates is tabulated below in which tons settlings filtered per hour has been classified and averaged according to the suspended solids in the settlings:

No. of Days Included in the Average	Average Per Cent Suspended Solids in Settlings	Average Tons Settlings Filtered Per Hour
10	1.5–1.9	7.73
25	2.0–2.4	7.60
9	2.5–2.9	7.43
4	3.0–3.9	7.43

These figures show that there is only a small difference in the quantity of settlings filtered per hour with relatively large differences in per cent suspended solids. These data are presented here to show that the filtering capacity is not flexible. Where heavier liming is practiced on high phosphate juices resulting in a large increase in volume of settlings, a larger number of Olivers would have to be provided to meet such a condition. This point is cited not as a disadvantage but as one of the limitations of the filter. At times the capacity of the filter can be increased by increasing the vacuum and the time of submergence, but such a condition is very uncertain because it depends entirely on the character of the settlings.

Acknowledgments

The writer takes this opportunity to thank E. W. Greene, manager, F. J. Fleener, and H. W. Robbins, of the Oahu Sugar Company, Ltd., for their cooperation and for furnishing data which are contained in this report. The writer also wishes to thank John F. Borden, of the Oliver Continuous Filter Company, for the valuable information supplied by him.

Influence of the Environment on Potato Mosaic Symptoms

A Review of a Paper by C. M. Tompkins*

There are well authenticated instances of mosaic disease of sugar cane in these Islands, from which the symptoms of the disease have completely disappeared with age. Mosaic disease of sugar cane is analogous to mosaic disease of potatoes in many ways, so that the results with potatoes, reported in the above-cited paper, seem applicable to the instances of such disappearance of mosaic symptoms in sugar cane.

* In *Phytopathology*, Vol. 16, No. 9, p. 581, September, 1926.

High Atmospheric Temperatures Mask Mosaic-Disease Symptoms in Potatoes

The author describes experiments in which mosaic-affected potato plants were placed in chambers at various temperatures. The symptoms of mosaic plants persisted when such plants were held at 59° F. or lower. On the other hand, similar plants exposed intermittently to temperatures of 75° F. or higher, lost the symptoms of mosaic disease completely. Mosaic-disease symptoms would reappear in these plants, if they were removed from the temperatures at 75° and replaced in the chambers at 59° F.

In other words, mosaic disease of potato plants became masked at temperatures of 75° or higher, but the symptoms recurred if the plants were removed again to a lower temperature.

The foregoing results were obtained by varying the temperatures of the air surrounding the plants. Raising the temperature of the soil was found to mask the symptoms of mosaic disease in potatoes in the early stages of growth of the plant, but did not have any effect on the symptoms of the disease on older plants.

Variations in Humidity, Light and Fertilizers Had No Effect on Mosaic Symptoms in Potatoes

Variations in soil moisture, humidity and light failed to decrease or intensify the symptoms of mosaic in potato plants. Increases or deficiencies of nitrogen, phosphoric acid or potash, in pot studies also failed to decrease or intensify the symptoms of mosaic disease.

The foregoing results by Tompkins suggest that the apparent recoveries which we have noted in sugar cane, are in reality not recoveries, but merely a masking of the symptoms of the disease, which will probably recur in colder seasons.

Along somewhat similar lines of thought, we have at the present time rather complete field experiments to determine the effect of nitrogen, phosphoric acid, and potash on mosaic disease of sugar cane.

(H. A. L.)

The Use of Portable Electric Lights in Boilers*

Although entirely aware of the dangers of electricity at high voltages, nearly everyone has become so familiar with the usual 110 volt lighting circuits that little thought is ever given to the possibility of serious accidents from such circuits. Yet there are several cases on record in which shock from a 110 volt circuit has proved fatal. In the Syracuse Bulletin of May 14, 1926, there appeared an account of the death from electric shock of Ralph Merrill, a millwright at the Skaneateles Mill of the Oswego Falls Corporation. The man was working inside of a boiler preparing it for internal inspection, and was using a lamp and

* From *The Locomotive*, Vol. XXXVI, No. 4, pp. 110-111.

extension cord from a 110 volt circuit. In some way, probably through a faulty connection and contact with the brass socket, he received a shock that resulted in his death.

In the September, 1925, issue of *The Boiler Maker* appeared a brief account of the death from electric shock of Michael O'Brien, while he was cleaning a boiler in the Administration Building, Montclair, N. J. Faulty insulation on the wire of a lamp which he held in his hand while in contact with the boiler is said to have allowed the current to pass through his body, with fatal results.

About two years ago an inspector called at the plant of the Detroit Brass and Malleable Company, Detroit, to make an inspection. Upon inquiring for the engineer, a helper set out to find him. The inspector soon received a call to the top of one of the boilers, and there on top of the tubes inside of the boiler lay the engineer. He had been dead about a half hour. The charge from a 220 volt lamp on an extension cord which he had taken into the boiler with him had burned a hole about the size of a five-cent piece near his heart.

Each of the above accidents happened with voltages such as one is likely to encounter in lighting circuits about an industrial plant. Whether a test was made to ascertain what voltage actually existed in each of the above cases is not stated, but in other somewhat similar cases tests were made but failed to show more than the normal voltage. It would appear then that even a circuit of "only 110" volts may, under certain circumstances, be dangerous, and conditions under which boilers are inspected and cleaned are by no means the safest. In the first place the boiler has an excellent electrical connection with a feed water pipe and hence is well grounded. Furthermore, the man working in a boiler is usually perspiring rather freely so that his moist hand or any part of his body that touches the metal makes a fairly good connection. It remains only for a short circuit through the brass lamp socket or a frayed cord to send a charge through the man.

Whether a shock from a 110 or 220 volt source will prove fatal depends likewise upon considerations other than merely good connections. For instance, the body resistance of different persons varies over quite a range, just as do all other physical characteristics. Hence, a man having a low electrical resistance would receive a heavier current than a man of higher resistance. Since the action of an electric shock is a paralyzing or tightening of the muscles, the condition of the heart is also a governing factor.

Still another factor is the matter of time or duration of the shock. If a person receiving a shock is in such a position that he immediately recoils or falls away and breaks the connection, serious injury is not likely to result from moderate voltages. However, if the paralyzing effect prevents voluntary action or causes the victim to fall in such a way as to maintain contact, then the prolonged action of the current, as would be expected, multiplies the effect. This is of particular importance to men working in boilers where much of the work is performed in tight places and in a recumbent position, sometimes even with the light resting on the body in order to free both hands for the work.

It is advisable, therefore, when using portable electric lights around boilers, first, to use only such as have the socket encased with some non-conducting material, and second, to examine the equipment beforehand to be sure it is safe for use.

(W. E. S.)

TABLE NO. 1

VARIETIES OF CANE

	H 109	Y. C.	D 1135	Yellow Tip	Striped Tip	Striped Mexican	Lahaina	Rose Bamboo	Others
H. C. & S. Co.	86	..	11	..	..	..	3	..	..
Oahu	92	..	6	..	..	..	..	..	2
Ewa	99	..	..	..	..	..	..	..	1
Waialua	72	2	21	..	..	..	1	..	4
Pioneer	74	..	3	..	..	16	..	..	7
Olaa	..	89	11	..	..	..	..	..	..
Maui Agr.	78	..	..	..	..	13	3	5	1
Haw. Sug.	76	..	17	..	..	..	..	..	7
Lihue	49	31	1	16	..	..	..	..	3
Onomea	..	82	1	17	..	..	..	..	..
Hilo	..	92	7	..	..	..	..	..	1
Honolulu	96	3	1	..	..	..	..	..	..
Haw. Agr.	..	45	17	..	..	3	..	9	26
Kekaha	50	..	16	..	..	..	32	..	2
Hakalau	..	77	1	22	..	..	..	..	..
Wailuku	85	..	2	..	..	7	4	..	2
Makee	63	22	..	13	..	..	..	..	2
McBryde	59	18	18	..	..	..	..	..	5
Honokaa	5	9	84	..	..	..	..	..	2
Laupahoehoe	..	39	21	39	..	..	..	..	1
Hamakua	..	31	60	7	..	..	..	..	2
Pepeekeo	..	86	4	10	..	..	..	..	..
Kahuku	74	20	..	..	..	..	5	..	1
Paauhau	7	16	56	19	..	..	..	..	2
Honomu	..	98	1	..	..	..	..	..	1
Koloa	55	26	..	14	..	..	..	..	5
Waiakea	..	98	2	..	..	..	..	..	..
Hutchinson	..	41	17	..	..	..	..	42	..
Hawi	13	..	28	4	51	3	..	1	..
Kaiwiki	..	44	31	4	15	..	..	..	6
Waianae	100	..	..	..	..	..	..	..	..
Kohala	..	18	42	9	14	..	..	..	17*
Kilauea	19	7	8	32	5	..	..	..	29†
Waimanalo	92	6	1	..	..	..	..	..	1
Kaeleku	..	100	..	..	..	..	..	..	..
Union Mill	..	7	8	5	80	..	..	..	..
Halawa	..	21	36	..	43	..	..	..	..
Waimea	90	..	..	..	..	..	10	..	..
Niulii	..	34	21	28	17	..	..	..	..
Olowalu	73	..	..	..	..	27	..	..	..
True Average 1926.	48.7	25.6	12.1	4.5	2.1	1.5	1.5	1.1	2.9
" " 1925.	42.7	30.7	11.9	2.7	2.1	2.0	3.1	1.0	3.8
" " 1924.	38.1	32.6	12.0	2.3	2.0	2.5	4.4	1.4	4.7
" " 1923.	30.7	36.3	11.2	1.2	1.6	3.1	8.4	1.5	6.0
" " 1922.	21.1	40.3	12.2	2.7	1.6	2.8	12.0	1.6	5.7
" " 1921.	15.0	45.1	11.0	1.2	1.8	3.0	17.4	1.0	4.5
" " 1920.	9.1	42.7	10.0	1.4	2.1	2.5	26.7	0.8	4.7
" " 1919.	6.8	46.4	7.2	0.3	2.6	1.8	29.1	2.1	3.7
" " 1918.	4.0	42.9	7.5	0.5	1.5	0.6	37.9	1.1	4.0

* 8% K 107

† Principally Badila.

Annual Synopsis of Mill Data

By W. R. Mc Allep

Though a few changes have been made in some of the tables, the Synopsis is presented in much the same form as in the past few years. It is again on the basis of the calendar year ending about the first of October, and factories are again listed in the tabulations according to the average size of the preceding five crops, except where otherwise noted. As sucrose data are now reported from seventy-five per cent of the factories, these data have been tabulated separately and averaged for the first time. Also for the first time it has been practicable to compile data for yield of cane per acre. Data for juice grooving and returner bar settings have been omitted. In recent years changes in these data from season to season have been comparatively few and a compilation every second or third year should serve all purposes. Data are included from all factories in the Association, representing the production of 782,643 tons of sugar.

Varieties of Cane

Eight varieties of cane are again classed as major varieties; that is, varieties making up 1 per cent or more of the total crop (Table 1). Changes in the proportion of these varieties have followed the general trend of the last few seasons. H 109 and Yellow Tip have materially increased. There is a tendency toward slight increases in D 1135 and Striped Tip, while Yellow Caledonia, Lahaina and Striped Mexican have materially decreased.

Almost one-half of the total production is H 109, establishing this variety in first place by a large margin. Yellow Caledonia and D 1135 are again second and third, the former making up approximately a quarter and the latter approximately one-eighth of the total. Yellow and Striped Tip rank fourth and fifth, Yellow Tip having displaced Lahaina, and Striped Tip both Lahaina and Striped Mexican. Ninety-three per cent of the total crop consists of these five leading varieties. Lahaina is now in seventh place, the proportion of this variety being less than half of what it was in 1925.

Minor varieties making up one per cent or more of the crop of any single plantation are in the following tabulation. The 1924 and 1925 figures are included for reference.

	Per Cent of Total Crop		
Variety	1924	1925	1926
Badila	.46	.35	.47
D 117	.49	.52	.15
H 146	.51	.26	.14
Uba	.03	.11	.10
K 107	...	...	.07
Yellow Bamboo	.02	.14	.03
W 4	...	...	.02
H 456	...	.11	...
H 20	...	.10	...
White Bamboo	.11	.06	...
H 227	...	.05	...
Total	1.62	1.70	.98

TABLE NO. 2

COMPOSITION OF CANE BY ISLANDS

	Hawaii	Maui	Oahu	Kauai	Whole Group
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Per cent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice	88.11	90.40	86.77	86.70	88.02
Quality Ratio	8.21	7.03	8.20	8.27	7.95
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Per cent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice	87.27	88.62	86.93	85.88	87.18
Quality Ratio	9.27	7.73	8.27	8.60	8.47
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Per cent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice	87.54	88.81	87.00	85.82	87.34
Quality Ratio	8.66	7.25	7.81	8.20	8.05
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Per cent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice	87.87	88.94	85.40	86.52	87.24
Quality Ratio	8.45	7.08	8.07	8.28	8.00
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Per cent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice	87.18	87.37	85.46	84.07	86.22
Quality Ratio	8.98	7.51	8.11	8.76	8.41
1922					
Polarization	12.07	13.95	13.61	13.03	12.97
Per cent Fiber	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice	87.17	87.88	86.18	85.80	86.84
Quality Ratio	9.19	7.75	8.04	8.36	8.45
1923					
Polarization	12.09	13.61	12.99	12.94	12.78
Per cent Fiber	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice	87.61	88.65	85.52	86.58	87.05
Quality Ratio	9.12	7.91	8.50	8.42	8.57
1924					
Polarization	12.44	14.34	13.48	13.34	13.26
Per cent Fiber	12.99	12.16	12.72	12.94	12.74
Purity 1st Expressed Juice	87.98	89.19	87.02	87.31	87.86
Quality Ratio	8.86	7.58	8.16	8.12	8.25
1925					
Polarization	12.35	14.42	13.52	13.24	13.22
Per cent Fiber	12.92	12.40	12.60	12.91	12.74
Purity 1st Expressed Juice	88.02	89.36	87.11	87.19	87.92
Quality Ratio	8.92	7.47	8.18	8.21	8.28
1926					
Polarization	12.53	14.66	13.40	13.03	13 24
Per cent Fiber	12.90	12.24	12.72	12.46	12.65
Purity 1st Expressed Juice	87.59	89.03	86.61	86.68	87.45
Quality Ratio	8.80	7.40	8.29	8.39	8.30

D 117, which in 1923 ranked as a major variety, has since steadily decreased until but .15 per cent is reported this season. H 146 has also steadily decreased from a maximum of .93 per cent in 1921 to .14 per cent this season. H 456, H 20, White Bamboo and H 227, listed as minor varieties in 1925, are not so classed this year. Two new varieties are included for the first time, each reported from a single plantation. These are K 107, reported from Kohala Sugar Company, and W 4 reported from Wailuku.

Quality of Cane

Notwithstanding an increase in cane polarization, the cane is of poorer quality than last year, due to lower purity. During the five preceding years there were increases in juice purity from season to season. This year a decrease of .47 brings the purity to a lower point than in 1924 and 1925, but higher than in other previous seasons since 1917. The quality ratio has increased from 8.28 to 8.30. This is a poorer quality ratio than in preceding seasons except 1918, 1921, 1922 and 1923.

Considering the Islands separately, we find decreases in purity in each instance. On Hawaii and Maui increases in polarization are large enough to more than offset the decreases in purity. Quality ratios are the best since 1920 on both of these Islands. On Oahu and Kauai there have been decreases in both polarization and purity. The quality ratio on Oahu is poorer than in any previous season except 1923; on Kauai it is poorer than in previous seasons except 1918, 1921 and 1923.

In quality of cane the Islands rank in the usual order; that is, Maui first, then Oahu, Kauai and Hawaii. The difference between Oahu and Kauai is small, amounting to but .1 in quality ratio.

Lower fiber is reported from all islands except Oahu, the average for the whole crop decreasing from 12.74 last year to 12.65. Figures for Hawaii and Kauai indicate consistent decreases in fiber from year to year; since 1920 on Hawaii and since 1921 on Kauai.

Tons cane per acre for the crop and for the five leading varieties are in the following table. These figures have been obtained by combining data reported for the Acreage Census and the Annual Synopsis. While a few discrepancies between the two sets of figures detract somewhat from the accuracy of the results, the figures for the crop and for the two leading varieties are probably accurate to within a few tenths, while probable errors in other figures will hardly exceed one ton per acre.

	Tons Cane Per Acre	
	1925	1926
Crop	53.3	54.4
H 109	69.4	69.1
Yellow Caledonia	44.8	45.0
D 1135	49.3	46.4
Yellow Tip	41.0	39.8
Striped Tip	31.5	37.0

The increase of 1.1 tons per acre for the entire crop seems due largely to increased acreage of H 109 in 1926.

TABLE NO. 3

True Averages of All Factories Except Those Now Using the Petree Process

	1922	1923	1924	1925	1926
Cane—					
Polarization	12.77	12.66	13.08	12.99	12.99
Fiber	13.03	12.91	12.82	12.80	12.71
Tons per ton sugar	8.76	8.68	8.40	8.45	8.50
Bagasse—					
Polarization	1.71	1.53	1.52	1.54	1.58
Moisture	41.31	41.29	41.26	41.25	41.09
Fiber	56.23	56.48	56.74	56.55	56.64
Polarization per cent cane	0.40	0.35	0.34	0.35	0.35
Pol. per cent. pol. of cane	3.11	2.76	2.63	2.69	2.73
Milling loss	3.05	2.71	2.68	2.73	2.79
Weight per cent cane	23.16	22.84	22.59	22.63	22.44
First Expressed Juice—					
Brix	18.23	17.99	18.34	18.14	18.24
Polarization	15.79	15.61	16.07	15.91	15.88
Purity	86.58	86.77	87.61	87.67	87.05
"Java ratio"	80.9	81.1	81.4	81.7	81.8
Mixed Juice—					
Brix	13.26	13.11	13.37	13.44	13.65
Polarization	11.07	11.00	11.31	11.38	11.48
Purity	83.50	83.87	84.56	84.67	84.12
Weight per cent cane	111.65	111.95	112.66	111.03	110.10
Polarization per cent cane	12.38	12.31	12.74	12.64	12.64
Extraction	96.89	97.24	97.37	97.31	97.27
Extraction ratio	0.24	0.21	0.21	0.21	0.21
Last Expressed Juice—					
Polarization	1.96	1.73	1.84	1.90	2.06
Purity	68.66	68.48	71.73	69.63	68.72
Maceration per cent cane	34.99	34.79	35.30	33.66	32.54
Syrup—					
Brix	63.11	63.33	63.18	63.63	64.21
Purity	84.81	85.40	86.02	85.95	85.49
Increase in purity	1.31	1.53	1.46	1.28	1.37
Lime used per cent cane	0.081	0.085	0.086	0.078	0.083
Press Cake—					
Polarization	1.96	2.20	2.16	2.17	2.49
Weight per cent cane	2.49	2.45	2.45	2.45	2.63
Polarization per cent cane	0.05	0.05	0.05	0.05	0.07
Pol. per cent. pol. of cane	0.38	0.43	0.40	0.41	0.50
Commercial Sugar—					
Polarization	96.88	96.88	97.20	97.23	97.29
Moisture	0.85	0.80	0.73	0.74	0.66
Weight per cent cane	11.41	11.53	11.91	11.83	11.77
Polarization per cent cane	11.06	11.17	11.58	11.50	11.45
Pol. per cent. pol. of cane	86.94	88.37	88.76	88.78	88.41
Pol. per cent pol. of juice	89.69	90.86	91.16	91.24	90.95
Final Molasses—					
Weight per cent cane	3.14	2.96	2.83	2.82	2.94
Sucrose per cent cane	1.07	0.99	0.97	0.93	0.99
Sucrose per cent pol. of cane	8.33	7.79	7.45	7.20	7.63
Sucrose per cent pol. of juice	8.60	8.01	7.65	7.40	7.84
Gravity solids	87.94	88.54	89.08	90.09	89.59
Gravity purity	38.60	37.68	37.81	36.97	37.62
Undetermined Losses—					
Polarization per cent cane	0.21	0.11	0.14	0.16	0.13
Pol. per cent. pol. of cane	1.28	0.65	0.76	0.92	0.73

Chemical Control

Three additional factories have reported sucrose data, bringing the total so reporting to thirty. These data have not been averaged in previous years, because of the comparatively small proportion of the crop represented. However, the proportion has increased from year to year until now approximately 80 per cent of the crop is produced by factories reporting sucrose data. A start has been made toward giving these data more detailed consideration by compiling Table 7, containing available sucrose data and true averages.

Molasses data also are more complete than in the past. But four factories have failed to report the amount of final molasses either on the basis of weights or measurements, against seven last year. Two additional factories have installed molasses scales, making a total of twenty-seven weighing the final molasses.

There has been no change in the number of factories weighing the juice, thirty-six factories reporting actual mixed juice weights, while the chemical control at four factories is still based on juice measurements.

The influence of a change in analytical methods must be taken into consideration when comparing molasses purities with figures for previous years. According to work at this Station, gravity purities by the new dry lead method average approximately .6 lower than by the old wet lead method. This difference is influenced by the density and purity of the sample and by the composition of the non-sugars. It therefore may be expected to vary in individual samples and in molasses from different factories. The .6 correction should be quite constant, however, for crop averages for different years. The new method was adopted prior to the 1925 season, and 1925 data, except for a moderate amount at the beginning of the season, were on this basis. The 1925 and 1926 averages, therefore, are not exactly on the same basis, but the difference is small and no material error will be involved in considering figures for these two years comparable. Comparisons will be made, therefore, assuming that .6 must be subtracted from molasses purities for years prior to 1925 to render them comparable with averages for subsequent years.

Lime figures also are not exactly comparable with figures for previous years. Formerly the total weight of lime was reported, a correction to available CaO being made only when hydrated lime had been used. Reports on the basis of available CaO have been requested this season, and as this request seems to have been quite generally complied with, the average figure for lime used is probably slightly low in comparison with previous data. Up to the present time, data for the amount of lime used have been the only basis available for judging clarification reactions and have, therefore, been of considerable significance. pH determinations are now made at most of the factories, and probably such data will be available for future Synopses, in which case it will no longer be necessary to base deductions as to the trend of clarification practice on the amount of lime used, a figure which at best is far from satisfactory for this purpose.

Table 4 contains comparisons of boiling house recovery with the available calculated on polarization data; also figures for molasses produced on the theoretical, assuming, as in previous seasons, the theoretical solids in molasses to be solids in syrup less solids accounted for in the sugar. Comparisons of boiling house recovery with the available, calculated on sucrose data, are in Table 5.

TABLE NO. 4

APPARENT BOILING-HOUSE RECOVERY

Comparing per cent available sucrose in the syrup (calculated by formula) with per cent polarization actually obtained.

Factory	Available*	Obtained	Recovery on Available	Molasses Produced on Theoretical†
H. C. & S. Co.	92.81	92.73	99.9	87.5
Oahu	92.07	92.48	100.4	74.7
Ewa	91.55	92.13	100.6	91.3
Waialua	91.19	91.87	100.7	87.0
Pioneer	92.74	93.36	100.7	85.7
Olaa	91.67	91.12	99.4	98.6
Maui Agr.	91.64	92.59‡	101.0	93.6
Haw. Sug	93.82	94.01	100.2	104.7
Lihue	90.75	91.33	100.6	82.1
Onomea	92.42	92.95	100.6	89.3
Hilo	91.62	91.59	100.0	86.1
Haw. Agr.	90.53	89.97	99.4	89.3
Kekaha	90.78	90.89	100.1	87.5
Hakalau	92.21	93.00	100.9	85.0
Wailuku	92.10	93.01	101.0	89.8
Makee	89.05	88.60	99.5	92.9
McBryde	91.53	90.56	98.9	96.7
Honokaa	90.15	90.81	100.7	91.8
Laupahoehoe	92.39	91.75	99.3	86.3
Hamakua	91.31	91.59	100.3	89.4
Pepeekeo	93.56	93.34	99.8	88.3
Kahuku	89.29	91.54	102.5	92.0
Paauhau	91.86	92.08	100.2	91.1
Honomu	92.43	92.36	99.9	92.9
Koloa	89.79	90.30	100.6	88.5
Waiakea	89.87	89.86	100.0	92.2
Hutchinson	89.42	88.67	99.2	96.6
Hawi	89.71	88.57	98.7	76.9
Kaiwiki	92.82	91.28	98.3	90.2
Waianae	86.97	82.87	95.3	...
Kohala	92.72	92.42	99.7	93.8
Kilauea	86.39	86.67	100.3	86.2
Waimanalo	89.38	90.04	100.7	86.8
Kaeleku	88.49	84.14	95.1	85.6
Union Mill	90.42	89.76	99.3	96.2
Halawa	90.14	89.37	99.1	...
Waimea	90.90	88.02	96.8	...
Niulii	91.30	89.17	97.7	...
Olowalu	90.86	86.71	95.4	62.5

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1 per cent has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

†Gravity solids in syrup, less solids accounted for in commercial sugar considered as theoretical gravity solids in final molasses.

‡ Sucrose.

This season figures for molasses produced on theoretical, based on the amount of molasses indicated by the S. J. M. formula, have been included in this table.

This year the number of factories reporting 100 per cent or more on available is larger than in any previous season, twenty in Table 4 and eleven in Table 5. However, one factory only has reported in excess of 101 per cent, a record equaled in but one previous season, 1921.

The true average of figures in Table 4 for molasses produced on theoretical is 90.4, a figure slightly higher than the average for the five previous seasons, 88.8. While wide variations are still evident in some of these figures, the general tendency from year to year has been toward fewer wide variations from the average. Figures in Table 5, for molasses produced on the theoretical as indicated by the S. J. M. formula, average slightly higher than corresponding figures in Table 4. This method of calculating the theoretical amount of molasses would have been used in previous Synopses had a greater number of factories reported sucrose data.

The "available" in Tables 4 and 5 represents the recovery indicated by the S. J. M. formula rather than the amount of sucrose it is possible to recover, for the calculations are based on purities as reported without reference to whether or not larger purity increases in clarification or lower molasses purities could have been realized. These calculations are therefore largely checks on the chemical control, though low figures for recovery on available may reflect losses. Such calculations are useful for disclosing large discrepancies in the chemical control. They have been particularly useful in the past, when juice entering, and molasses leaving the house were largely estimated from measurements. Brix hydrometers were less carefully calibrated and the chemical control in general was less accurate than at present. Data now available, however, give many indications that the value for available sucrose as calculated is somewhat lower than the true theoretical figure for available. Notwithstanding more reliable chemical control, coincident with the use of larger amounts of lime in clarification and generally better boiling house work in recent years, an increasing number of factories have reported in excess of 100 per cent recovery on available. As previously mentioned, the maximum number have so reported this year. Critical examination of control methods discloses several small factors tending toward low figures for calculated available. While this does not interfere with the use of these calculations for disclosing comparatively large discrepancies in control data, if closer comparisons are desired the influence of these factors must be taken into consideration. While this subject was taken up in the 1924 Synopsis, we will consider it again briefly. The following four factors were discussed at that time:

1. Solids in sugar are determined by drying. "True" purity figures thus secured are slightly higher than gravity purities on which the calculation is based. The calculated available decreases as sugar purity increases. Consequently, as our figure for sugar purity is relatively higher than the syrup and molasses purities, this tends toward low figures for available.

2. There was an error in the former method of determining sucrose in molasses which resulted in a purity figure relatively too high. As an increase in molasses purity reduces the calculated available, this also has tended toward low figures for available. This error is now corrected.

TABLE NO. 5

TRUE BOILING-HOUSE RECOVERY

Comparing per cent sucrose available and recovered

Factory	Available	Obtained	% Recovery on Available	Molasses Produced on Theoretical*
H. C. & S. Co.	92.73	92.15	99.4	90.2
Oahu	92.21	91.66	99.4	76.4
Ewa	91.71	91.00	99.2	92.3
Waialua	91.06	90.63	99.5	84.5
Pioneer	92.71	92.71	100.0	85.0
Maui Agr.	91.64	92.57	101.0	90.1
Haw. Sug.	93.93	93.31	99.3	108.9
Lihue	90.85	90.36	99.5	82.0
Onomea	92.73	92.76	100.0	93.8
Hilo	91.32	91.54	100.2	85.7
Haw. Agr.	90.71	89.22	98.4	95.3
Hakalau	92.15	92.66	100.6	83.4
Wailuku	92.15	92.59	100.5	87.9
Makee	89.12	87.98	98.7	96.7
McBryde	91.64	89.61	97.8	104.3
Honokaa	90.11	90.36	100.3	91.2
Laupahoehoe	92.07	91.45	99.3	88.0
Hamakua	91.20	91.29	100.1	90.2
Pepeekeo	93.32	93.04	99.7	87.9
Kahuku	89.37	90.39	101.1	87.3
Paauhau	91.75	91.91	100.2	90.1
Honomu	92.38	91.85	99.4	94.1
Koloa	89.98	89.19	99.1	89.9
Waiakea	89.66	89.20	99.5	92.5
Hutchinson	89.44	88.30	98.7	102.1
Kilauea	86.53	85.56	98.9	86.3
Waimanalo	89.21	89.64	100.5	84.2
Union Mill	90.10	89.58	99.4	98.8
Olowalu	90.77	86.29	95.1	74.4

* Calculated by the S. J. M. formula.

3. A discrepancy in the Brix of final molasses. This is determined in a solution containing a higher concentration of non-sugars than the syrup, it being impracticable to make these determinations at equivalent concentrations. The relative amount of non-sugars indicated by the Brix decreases as the concentration of non-sugars in the solutions in which the determination is made increases. Consequently the value obtained for molasses purity is relatively higher than the syrup purity. This factor also tends to reduce the figure for calculated available.

4. Volatilization of solids during boiling operations. This undoubtedly takes place to some extent. It amounts to increasing the purity over that of the syrup on which the calculation is based. This also tends toward a low figure for available.

To the above may be added two additional factors:

5. Formation of scale in the pans. This affects the calculation in the same way as volatilization of solids. While this factor is very small, it should be noted that when the scale-forming constituents were in solution in the syrup they increased the gravity solids by considerably more than their actual weight.

6. Precipitation of non-sugar subsequent to the syrup stage. Non-sugar crystals, largely inorganic in composition, can almost invariably be found in massecuite and molasses. Organic matter also separates out due to concentration and decrease in pH. In so far as this precipitated matter is retained in the commercial sugar, the effect is that discussed under No. 1 above. The remainder, as suspended matter in molasses, influences the reading of the Brix hydrometer much less than when in solution in the syrup. This is another factor tending toward a relatively low molasses Brix and therefore a relatively high purity. It therefore tends to depress the calculated available.

These factors all influence the calculations in the same direction. So far as conclusions can be drawn from available data, the combined effect is not large, probably in the neighborhood of one per cent in calculations on a true sucrose basis.

The influence of these factors on the calculated theoretical amount of molasses is in the opposite direction, and is much larger. So far as can be inferred from data in recent Synopses, the calculated amount of molasses is in the neighborhood of 10 per cent too high.

Deerr's S. J. M. formula, used in these calculations, divides a syrup of a given purity into molasses and sugar of given purities with mathematical accuracy. Discrepancies are due to data on which the calculation is based rather than the calculation itself. The error in molasses analysis is now corrected and need not be considered further. Volatilization of solids and scale in the pans are probably of minor importance. Factors 1, 3 and 6, which are probably responsible for the greater part of the discrepancy, are due to basing calculations on gravity solids as indicated by the Brix hydrometer, and would be eliminated if the control were based on the actual weight of solids. Unfortunately, methods so far developed for determining total solids are not well suited to routine factory control, and changing to this basis is impracticable until more suitable methods are developed. The writer wishes to emphasize the point that the influence of these factors should be taken into consideration in drawing conclusions from factory control data.

TABLE NO. 6
GRAVITY SOLIDS AND SUCROSE BALANCES

Factory	GRAVITY SOLIDS PER 100 GRAVITY SOLIDS IN MIXED JUICE				SUCROSE PER 100 SUCROSE IN MIXED JUICE			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	3.3	80.6	14.1	2.0	0.88	91.34	6.50	1.28
Oahu	4.1	78.2	13.2	4.5	0.73	91.00	5.91	2.36
Ewa	5.4	75.1	17.5	2.0	0.41	90.63	7.62	1.34
Waialua	3.0	77.2	16.4	3.4	0.45	90.22	7.52	1.81
Pioneer	4.8	78.2	14.5	2.5	0.67	92.09	6.16	1.08
Maui Agr.	...	82.4	16.5	1.1	....	92.57	7.53	—0.10
Haw. Sug	5.2	80.3	15.2	—0.7	0.38	92.96	6.58	0.08
Lihue	3.2	75.1	17.4	4.3	0.74	89.69	7.44	2.13
Onomea	6.1	77.4	15.5	1.0	0.13	92.64	6.81	0.42
Hilo	7.5	74.1	15.9	2.5	0.30	91.27	7.42	1.01
Honolulu	4.0	74.6	19.7	1.7	0.44	88.65	8.87	2.04
Haw. Agr.	3.7	75.3	18.8	2.2	0.47	88.80	8.81	1.92
Hakalau	3.5	78.5	15.4	2.6	0.14	92.53	6.54	0.79
Wailuku	4.1	79.2	15.0	1.7	0.52	92.11	6.86	0.51
Makee	3.1	72.7	22.5	1.7	0.51	87.53	10.47	1.49
McBryde	3.6	75.8	19.7	0.9	0.25	89.39	8.70	1.66
Honokaa	5.6	73.7	19.1	1.6	0.58	89.84	8.97	0.61
Laupahoehoe	3.3	79.4	14.8	2.5	0.34	91.14	6.96	1.56
Hamakua	...	81.7	16.3	2.0	....	91.29	7.94	0.77
Pepeekeo	4.0	79.2	14.6	2.2	0.21	92.84	5.86	1.09
Kahuku	3.9	72.7	21.2	2.2	0.34	90.08	9.25	0.33
Paauhau	4.6	77.2	16.5	1.7	0.15	91.77	7.42	0.66
Honomu	4.9	77.1	16.5	1.5	0.26	91.61	7.15	0.98
Koloa	5.5	72.3	19.4	2.8	1.05	88.25	8.92	1.78
Waiakea	4.3	75.5	18.3	1.9	0.48	88.77	9.51	1.24
Hutchinson	7.9	70.8	20.7	0.6	0.67	87.71	10.69	0.93
Kilauea	3.6	67.5	24.3	4.6	0.96	84.74	11.51	2.79
Waimanalo	5.6	72.4	18.8	3.2	0.50	89.19	9.03	1.28
Union Mill	4.7	75.7	18.9	0.7	0.91	88.76	9.69	0.64
Olowalu	4.7	72.0	14.6	8.7	0.59	85.78	6.83	6.80

Gravity solids and sucrose balances for factories reporting on a sucrose basis are in Table 6.

While data in Tables 4, 5 and 6, considered in relation to the factors discussed above, permit us to draw fairly definite inferences as to whether or not there are material discrepancies in control figures, arriving at definite standards on which to base comments on the accuracy of such figures is somewhat unsatisfactory, not only because this involves deciding on what should be considered moderate errors, but also because of our limited knowledge of the exact influence of the factors previously discussed. Assuming tentatively that reasonably accurate data do not indicate negative undetermined losses of either solids or sucrose, more than 101 per cent recovery of sucrose on available, or more than 95 per cent of the calculated amount of molasses, particularly on the basis of calculations in Table 5, we find the following factories exceeding these limits: A negative undetermined loss of solids at Hawaiian Sugar Company; a negative undetermined loss of sucrose at Maui Agricultural Company; over 101 per cent recovery of sucrose on available at Kahuku; more than 95 per cent of molasses on available at Hawaiian Sugar Company, McBryde, Hutchinson, Union Mill and Hawaiian Agricultural Company. A normal amount of molasses is shown for the latter factory, however, by figures in Table 4.

In the last few years there have been changes in the basis on which data from certain factories have been reported, influencing many of the averages and necessitating supplementary calculations when studying data to ascertain the probable effect on figures under consideration. This has materially complicated the preparation of the Synopsis and in many cases it has been found impracticable to draw deductions even where such deductions would have been of considerable significance. The disturbing effect of Petree process figures has been discussed in previous Synopses and a table containing averages for the factories which do not use this process has been compiled each year to partially remedy this difficulty. The influence of a change in the method of molasses analysis must also be taken into consideration when comparing molasses data with previous years. Another disturbing factor is averaging some sucrose data with data on a polarization basis. For many years one of the larger factories has reported sucrose only for mixed juice, syrup and sugar, instead of both polarization and sucrose. Though a discrepancy is introduced by including such data in polarization averages, this has not complicated comparisons with other seasons, as data have been on the same basis from year to year. However, in 1923 a second, and in 1925 a third large factory reported on this basis. As but one factory changed in a single season, discrepancies in the averages between any two years have been small in most instances, and to avoid complicating the Synopsis these discrepancies have been pointed out only where they were of sufficient size to influence conclusions. This season polarization data have been secured from these two factories, and many of the averages have been influenced to the extent that it has been necessary to prepare the following table, calculated on the basis of sucrose data from these two factories. Where figures in this table differ from averages in the large table and Table 3, comparisons with 1925 data will be on the basis of the figures given below. These will be referred to as "figures calculated on a basis comparable with last season."

TABLE NO. 7

SUCROSE DATA

Factory	Cane Sucrose*	MIXED JUICE		SYRUP		SUGAR		Undetermined Loss per 100 Sucrose* in cane
		Sucrose	Gravity Purity	Gravity Purity	Increase in Purity	Sucrose	Sucrose per 100 Sucrose* in cane	
H. C. & S. Co	14.97	12.46	88.80†	88.80	0	97.43	89.43	1.25
Oahu	14.08	12.61	86.67	87.58	0.91	97.90	88.76	2.30
Ewa	13.14	11.27	83.67	85.63	1.96	97.53	88.84	1.32
Waialua	13.89	12.06	85.90	86.30	0.40	97.53	87.71	1.76
Pioneer	14.60	13.37	86.26	87.38	1.12	98.14	89.83	1.06
Maui Agr	15.37	11.67	87.48†	87.60	0.12	97.77	88.81	—0.10
Haw. Sug	14.80	12.94	88.03	89.28	1.25	97.79	90.72	0.08
Lihue	12.64	12.43	84.73	84.60	—0.13	97.86	86.88	2.06
Onomea	12.18	10.26	85.36	87.58	2.22	97.79	91.47	0.41
Hilo	12.21	10.59	84.31	86.18	1.87	97.68	89.63	1.00
Honolulu	14.04	11.82	85.34	87.25	1.91	100.0	86.26	1.99
Haw. Agr	12.09	11.69	85.27	86.23	0.96	97.63	86.01	1.86
Hakalau	12.41	10.40	85.10	86.00	0.90	97.04	91.51	0.78
Wailuku	14.29	11.61	86.84	87.70	0.86	97.71	90.73	0.50
Makee	12.06	11.03	83.44	84.13	0.69	97.99	84.12	1.43
McBryde	13.64	11.95	85.06	86.10	1.04	97.47	86.88	1.61
Honokaa	11.44	10.64	83.19	84.57	1.38	97.29	86.03	0.58
Laupahoehoe	13.11	10.69	87.70	88.49	0.79	97.87	88.52	1.51
Hamakua	13.54	13.47	88.10†	88.32	0.22	97.77	88.70	0.75
Pepeekeo	12.53	11.31	85.62	87.10	1.48	97.72	90.83	1.07
Kahuku	12.25	10.55	81.40	82.33	0.93	97.91	87.78	0.32
Paauhau	12.45	11.05	84.61	86.63	2.02	97.82	89.46	0.65
Honomu	12.70	10.63	84.44	86.70	2.26	97.74	89.90	0.96
Koloa	12.75	11.15	83.09	84.30	1.21	97.73	85.44	1.73
Waiakea	13.42	12.17	85.64	86.79	1.15	97.29	84.69	1.18
Hutchinson	12.06	11.24	84.32	85.80	1.48	97.78	84.02	0.89
Kilauea	11.37	10.61	80.81	81.00	0.19	98.33	82.47	2.71
Waimanalo	11.96	10.70	81.90	84.14	2.24	97.70	87.91	1.26
Union Mill	12.57	11.84	85.80	86.80	1.00	96.62	83.86	0.60
Olowalu	14.14	11.78	84.45	85.70	1.25	96.81	83.77	6.64
True Average	13.39	11.69	85.51	86.68	1.17	97.77	88.32	1.24

* Polarization in bagasse and press cake has been used in this calculation, no account being taken of the difference between sucrose and polarization in these products.

† Clarified juice.

	Large Table	Table 3
Cane Polarization	13.26	13.01
Java Ratio	81.84	81.9
Mixed Juice Polarization	11.60	11.50
Mixed Juice Purity	84.76	84.26
Mixed Juice Polarization % Cane	12.90	12.66
Syrup Purity	85.90	85.63
Sugar Polarization	97.34	97.34
Recovery % Polarization in Cane	88.53	88.36
Recovery % Polarization in Juice	91.03	90.83
Sucrose in Molasses % Pol. in Cane	7.50	7.62
Sucrose in Molasses % Pol. in Juice	7.71	7.83
Undetermined Loss	.72	.80

Milling

This year the average grinding rate has increased materially while the average extraction has decreased slightly. Data for grinding rates and also tons pressure per foot of roller for the last few seasons are in the following table:

Year	Tons Cane Per Hour	Tonnage Ratio	Tons Pressure Per Linear Foot of Roller
1920	39.34	...	...
1921	36.58	1.40	...
1922	39.93	1.54	65.2
1923	42.03	1.56	66.2
1924	43.63	1.62	66.9
1925	45.31	1.71	66.5
1926	46.43	1.78	67.4

The increase in grinding rate over last season is 1.12 tons per hour, corresponding to an increase of .07 in tonnage ratio. Such increases conform to the tendency toward higher grinding rates during the past few seasons. The tendency has been general this year, approximately two-thirds of the factories reporting higher tonnage ratios.

The above data for tons pressure per linear foot of roller show a well-defined tendency toward higher pressures during the past few seasons. The reported increase over last season is slightly less than one ton per foot of roller.

Maceration is very nearly the same as in the previous season, though the slight difference, a reduction from 33.63 to 33.61, conforms to the tendency toward lower maceration during the past seven years. Twenty-one factories report decreases, against nineteen reporting increases. It was somewhat interesting to note that but five factories report as heavy maceration as the average for all factories in 1919, the year in which maceration reached a maximum.

Moisture in bagasse has decreased from 41.56 to 41.48. Bagasse fiber has increased slightly: 56.18 to 56.19. With slightly higher fiber in bagasse and lower fiber in cane the calculated weight of bagasse per 100 cane has been reduced from 22.67 to 22.52. Polarization in bagasse has increased from 1.58 to 1.62, an increase large enough to offset the reduction in weight and increase the loss in bagasse per

TABLE NO. 8—MILLING RESULTS

Showing the Rank of the Factories on the Basis of Milling Loss.

Rank	1925 Rank	Factory	Milling Loss	Extraction Ratio	Extraction	Maceration	Tonnage Ratio	Tonnage Fiber Ratio*
1	1	Hakalau......	1.10	0.10	98.88	38.46	1.53	19.14
2	3	Onomea.......	1.21	0.10	98.72	38.47	1.83	23.53
3	2	Waimanalo....	1.30	0.11	98.56	31.62	2.06	26.92
4	4	Hilo..........	1.63	0.13	98.19	36.02	1.65	22.24
5	6	Kekaha.......	1.78	0.13	98.45	31.14	1.60	18.95
6	8	Wailuku......	1.84	0.13	98.48	41.13	1.18	13.76
7	7	Honomu......	1.94	0.15	98.12	38.42	1.49	18.12
8	11	Ewa..........	2.13	0.16	98.00	36.63	1.71	20.76
9	9	Pepeekeo.....	2.17	0.17	97.82	28.88	1.62	20.28
10	15	Kahuku.......	2.28	0.19	97.41	36.31	1.54	21.13
11	5	Olowalu......	2.31	0.17	97.62	41.13	1.61	23.18
12	10	Paauhau......	2.41	0.20	97.47	31.95	1.19	15.40
13	23	Oahu.........	2.66	0.19	97.51	31.91	1.86	24.11
14	30	H. C. & S. Co..	2.67	0.18	97.89	37.43	1.90	22.33
15	22	Hamakua.....	2.67	0.20	97.15	24.02	1.50	21.62
16	16	Pioneer.......	2.76	0.19	97.52	30.65	2.18	28.25
17	13	Kilauea.......	2.78	0.25	97.27	24.23	1.52	16.64
18	17	McBryde......	2.78	0.21	97.16	34.78	1.24	17.04
19	18	Haw. Sug......	2.85	0.19	97.56	33.51	1.43	17.95
20	14	Koloa.........	2.89	0.23	96.78	35.63	1.37	19.19
21	19	Laupahoehoe..	2.90	0.22	97.10	41.08	1.61	20.80
22	27	Haw. Agr.....	2.96	0.25	96.82	22.80	1.84	23.63
23	20	Waialua......	3.00	0.22	97.17	34.98	2.29	29.52
24	21	Honolulu......	3.21	0.23	97.27	38.56	1.54	18.50
25	24	Olaa..........	3.21	0.24	96.88	32.01	2.03	26.11
26	12	Lihue.........	3.35	0.27	96.82	20.31	1.90	22.50
27	29	Kohala.......	3.41	0.24	97.14	37.70	1.65	19.37
28	26	Makee........	3.64	0.30	96.07	28.16	2.01	25.89
29	28	Waimea.......	3.65	0.27	96.69	25.83	1.49	18.01
30	25	Waianae......	3.71	0.29	95.86	41.90	1.58	22.93
31	36	Honokaa......	3.82	0.34	95.72	27.17	1.58	19.99
32	33	Hawi.........	3.93	0.30	96.39	27.35	1.70	20.59
33	32	Kaiwiki......	3.97	0.29	96.15	31.87	1.68	21.99
34	37	Kaeleku......	4.15	0.36	95.07	32.58	1.83	25.40
35	35	Waiakea......	4.37	0.33	95.37	31.17	1.54	21.70
36	34	Hutchinson....	4.52	0.38	95.76	22.23	1.89	21.22
37	38	Union Mill....	4.84	0.39	94.45	26.67	1.83	26.33
38	31	Maui Agr.....	5.10	0.33	95.94	51.45	2.43	29.82
39	39	Halawa.......	5.84	0.46	93.66	26.52	1.62	22.24
40	40	Niulii.........	6.30	0.50	93.28	20.05	1.73	23.41

* Tonnage ratio multiplied by per cent fiber in cane.

cent polarization in cane from 2.71 to 2.75. The corresponding decrease in extraction is from 97.29 to 97.25. The decrease in extraction is somewhat less than if the cane had been as high in fiber as last year. The increase from 2.82 to 2.88 in loss per cent fiber in the bagasse or milling loss is relatively larger than the decrease in extraction.

At H. C. & S. Company, Petree process mud has been taken from the mills with a gain in extraction, while at Maui Agricultural Company the mill has been under reconstruction during the grinding season, seriously handicapping the work and causing a loss in extraction. In each case the influence of the change on the average for extraction has been as great as the difference between the averages for this year and the previous season. The trend toward lower extraction indicated by the averages, however, is also indicated by data for individual factories, twenty-six reporting increases in milling loss against twelve reporting decreases.

No factory has equaled previous records in either extraction, extraction ratio, or milling loss. The number of factories reporting over 98 extraction has decreased from nine in 1925 to eight this year. We also find a decrease of one in the number of factories reporting under 2.0 milling loss, seven factories so reporting against eight last year.

Factories are listed in the order of the size of the milling loss in Table 8. Several changes have been made in this table following suggestions that have been received. A second column at the left of the table indicates the 1925 ranking. Maceration, tonnage ratio and tonnage fiber ratio have been included, data for milling machinery being omitted. Tonnage fiber ratio, a figure used to a considerable extent in the Philippines, is the tonnage ratio multiplied by the per cent fiber in cane. The largest changes in relative rank are improvements of 10 and 16 by Oahu and H. C. & S. Company, and a drop of 14 by Lihue. Kahuku, Hamakua, Hawaiian Agricultural and Honokaa have all materially bettered their relative standing, while Olowalu, Koloa, Waianae and Maui Agricultural Company have all dropped five or more places.

Data for non-Petree process factories, calculated to a basis comparable with the previous seasons indicate a decrease of .21 in the drop in purity from first expressed to mixed juice. The tendency has been quite general, twenty-three of these factories reporting a smaller drop, against thirteen larger. This may reflect either cleaner conditions around the mill, less trash on the cane, or both.

Boiling House Work

Clarification: Averages for non-Petree process factories in Table 3 indicate an increase in lime consumption, a larger increase in purity, higher recovery on available, and smaller undetermined loss. These changes conform to the relation shown by data in this table for other seasons. With the single exception of changes between the seasons 1923 and 1924, changes in increase in purity and recovery on available have been in the same direction as changes in the amount of lime used, while changes in the figures for undetermined loss have been in the opposite direction.

Lime consumption has increased from .078 to .083 per cent on cane; possibly the increase is slightly greater, due to the change in the way lime is reported. The improvement in the increase in purity is from 1.28 to 1.37. The improvement

has not been general, but sixteen out of thirty-seven factories reporting a larger increase. It reflects rather the results secured at the larger factories, eight of the ten largest reporting larger increases. While on the basis of average figures, the increase in lime has been accompanied by a larger increase in purity, examination of data for individual factories this season does not show a consistent relation. There are some indications that this may be due to a number of factories using the full amount of lime giving the maximum increase in purity, or even in excess of this amount, though study of this point is considerably complicated by the incomplete way in which lime used at the filter presses is reported, and also possibly to the change in the basis for reporting the amount of lime. When pH data are available the study of clarification on the basis of results secured by factories as a whole will be greatly facilitated. However, in view of the consistent manner in which averages for increase in purity, recovery on available, and undetermined loss in different seasons follow fluctuations in the amount of lime used, it seems reasonable to infer that, considered as a whole, the amount of lime used in clarification is still below the point giving the best results.

Averages for all factories in the large table also show an increase in lime, an increase in recovery on available, and a decrease in undetermined loss. The increase in lime, .002 per cent, is much smaller than shown in Table 3. This is also true of changes in recovery on available and undetermined loss. The latter figure, recalculated to a basis comparable with last season, is but .01; a change too small to be of significance in a figure such as undetermined loss, which is influenced by the sum of errors in all other figures in the polarization balance. It is, however, in the expected direction.

Filter Presses: Data for filter press work are much less satisfactory than last year. Twenty-two out of thirty-seven factories report an increase in press cake per cent cane; the same number report an increase in polarization of press cake, resulting in an increase in weight from 2.45 to 2.63 per cent on cane, an increase in polarization from 2.17 to 2.49, and an increase in the loss per cent polarization of cane from .41 to .50. The above refers to data in Table 3. The average loss in press cake per cent polarization of cane for all factories, shown in the large table, has increased from .38 to .50; a larger increase than is shown in Table 3. This is due to losses in mud reported from H. C. & S. Co., where this year all the mud has been treated in Kopke centrifugal separators, none being returned to the mill. Notwithstanding the limited capacity of the centrifugal installation, which limits the extent to which the sucrose content of the mud can be reduced, data reported show a smaller combined loss of sucrose in bagasse and Kopke mud than the loss in bagasse alone when settlings were returned to the mill. It should be noted in this connection that grinding rates are higher than when the straight Petree process was in use, tending to increase the loss in bagasse, and that when the mud was returned to the mill the increased weight of bagasse due to solids thus added was not taken into consideration in calculating the loss of sucrose in bagasse. Both of these factors tend to decrease the difference noted above.

Now that the loss in press cake has reached a half of one per cent of the total sucrose in the cane, it deserves serious attention. In the writer's opinion, an adequate solution of this problem is not so much increasing capacities along present lines as it is finding equipment capable of performing this operation efficiently.

Evaporation: The Brix of the syrup has increased from 63.65 to 64.04, the highest figure on record. During the past few seasons calculations based on mixed juice and syrup densities have indicated a consistent increase in the amount of water evaporated per hour. The increase over last season is 2.6 per cent.

Commercial Sugar: The commercial sugar is higher in polarization. This year's average, 97.30, is the highest since 1911. While figures in the larger table indicate an increase of .08 in polarization, calculated to a basis comparable with 1925, the increase is .12. Moisture in the sugar has decreased in greater proportion than the increase in polarization, reducing the deterioration factor to .251. This is the first time that the average deterioration factor has been reduced to this point. The increase in commercial sugar polarization accounts for approximately .04 of the decrease in recovery.

Low Grade Work: The combined effect of higher grinding rate, lower syrup purity and higher polarizing sugar, has been an increase of slightly over seven per cent in the duty imposed on the low grade equipment. Twenty-one out of thirty-seven factories report higher molasses purity this year. The average purity has increased .65. As noted in a previous paragraph, the change in the method for determining sucrose in molasses has reduced the gravity purity by .6 in comparison with figures for years prior to 1925. This year's average, allowing for this difference, is higher than previous averages since 1922. The weight of molasses per cent cane is greater than in 1924 and 1925, as is also the loss per cent polarization in the cane.

No factory has equaled the record of 32.46 for gravity purity of molasses made by Kahuku in 1925.

Recovery

The following comments all refer to figures calculated to a basis comparable with last year, where these figures differ from averages in the large table. The first expressed juice purity is .47 lower than last season. Smaller decreases from first expressed to mixed juice and larger increases from mixed juice to syrup, however, have reduced the difference between syrup purities in the two seasons to .37.

Boiling house recovery has decreased from 91.59 to 91.03 and recovery per cent polarization in cane from 89.11 to 88.53; decreases of .56 and .58 respectively. The increase in sugar polarization corresponds to a decrease of approximately .04 in recovery, so on the basis of recovery of available sugar we may consider the decrease .54 instead of .58. The decrease in recovery corresponding to lower initial purity amounts to slightly over one-half the decrease. Higher molasses purity is the next largest factor. Indirectly, a considerable part of this increase in molasses purity may be credited also to lower juice purity, this factor materially increasing the duty imposed on low grade equipment. Other factors tending toward lower recovery are increased loss in press cake and lower extraction. Partially offsetting these factors are a smaller decrease in purity at the mill, a larger purity increase in clarification, and a slightly better recovery on available. So far as can be inferred from these data, slightly less than one-half of the decrease in recovery is attributable to results secured in manufacture, while lower initial purities correspond to slightly more than one-half of the decrease.

This conclusion is closely confirmed by data for quality ratio and tons of cane required to make a ton of sugar. These figures, with corresponding figures for yield per cent cane, carried to the third decimal place, follow:

	Tons Cane Per Ton Sugar		Yield Per Cent Cane	
	Quality Ratio	Tons Per Ton Sugar	Theoretical	Actual
1925	8.277	8.266	12.082	12.098
1926	8.305	8.313	12.041	12.029
Difference			.041	.069

The decrease in yield of sugar per cent cane, corresponding to the change in quality ratio, is .041, while the actual decrease in yield of commercial sugar is .069. On this basis also we have an indication that somewhat more than one-half of the decrease in recovery is attributable to poorer quality of cane and somewhat less than one-half to manufacturing operations.

Actual and Theoretical Recoveries

Comparisons of actual and theoretical recoveries calculated on the basis of 100 per cent extraction, 37.5 gravity purity molasses and no other losses, are in Table 9. As this table has been the subject of considerable comment and criticism, a discussion of these calculations and reasons for continuing this table in the Synopsis seems desirable. It was first presented in the Synopsis under the title "Factory Efficiency," the term efficiency referring to the proportion of the available sugar in the cane actually recovered. Later it was recognized that these calculations did not give sufficiently consistent results to merit the term efficiency. The title was then changed to "Comparisons of Actual and Calculated Recovery," and the table presented with the comment that these data should be considered approximate rather than exact.

One defect in these calculations is that the relative standing is influenced by juice purities. If, for instance, the standard for molasses purity is lower than the purity attained in practice, factories with low juice purities will be ranked lower than the quality of the work warrants. The influence of this factor can be reduced to a minimum, though not eliminated, by taking average performance as the standard. Originally the standard for molasses purity was lower than that attained in practice. This was later changed to 37.5 purity, a figure approximating the average. While basing the standard on average performance results in figures of over 100 per cent in many instances, the writer does not consider this a material objection. As variations in cane fiber have an influence similar to variations in juice purity, average performance would be preferable as the standard for extraction. This change has not been made so far, partly because in most cases the influence of this factor is not large, and also because of the uncertainty as to how the purity of the mixed juice should be calculated at a given extraction other than 100 per cent. At 100 per cent extraction, mixed juice purity is assumed to be that of the normal juice. Another factor influencing the consistency of these calculations is the purity to which the molasses can be reduced with a given efficiency of low grade work. From experimental work at this Station and observations at

TABLE NO. 9

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 4) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau	98.88	101.56	100.56
2	Onomea	98.72	100.92	99.90
3	Ewa	98.00	101.07	99.39
4	Wailuku	98.48	100.03	98.74
5	Pepeekeo	97.82	100.83	98.74
6	Honomu	98.12	100.29	98.68
7	Pioneer	97.52	100.64	98.63
8	Waimanalo	98.56	99.78	98.57
9	Hilo	98.19	99.75	98.21
10	Lihue	96.82	100.98	98.20
11	Kekaha	98.45	99.20	98.02
12	Paauhau	97.47	100.16	97.93
13	Haw. Sug..........	97.56	100.06	97.82
14	Waialua	97.17	99.88	97.46
15	Oahu	97.51	99.56	97.41
16	Kilauea	97.27	99.43	97.19
17	Koloa	96.78	99.75	97.12
18	Maui Agr..........	95.94	100.15	96.70
19	H. C. & S. Co.......	97.89	98.28	96.43
20	McBryde	97.16	98.96	96.43
21	Honokaa	95.72	100.04	96.25
22	Kohala	97.14	98.59	96.16
23	Hamakua	97.15	98.44	96.04
24	Laupahoehoe	97.10	97.97	95.37
25	Haw. Agr..........	96.82	98.20	95.37
26	Olaa	96.88	97.91	95.28
27	Makee	96.07	98.67	95.18
28	Hawi	96.39	97.15	94.04
29	Kaiwiki	96.14	96.96	93.54
30	Waimea	96.69	96.07	93.26
31	Hutchinson	95.76	96.84	93.12
32	Waiakea	95.37	97.07	93.04
33	Olowalu	97.62	94.48	92.61
34	Halawa	93.66	97.53	91.72
35	Union Mill	94.45	96.32	91.28
36	Niulii	93.28	96.99	90.91
37	Kaeleku	95.07	94.34	90.06
38	Waianae	95.86	92.92	89.46

some of the factories, it would seem that a variation of three in gravity purity should be about the maximum influence of this factor. After studying these figures for a number of years, it is the writer's opinion that the maximum total discrepancy due to these factors is not likely to exceed two in the third column of the table. Efficiency of clarification is not a factor in these calculations, no equitable method for evaluating this on a percentage basis having come to the writer's attention.

Some of the criticisms of this table have been that no allowance is made for difference in available equipment. Making allowances for the efficiency of equipment as suggested, involves estimating what should be expected of the equipment at each factory. While statistics published in Annual Synopses, considered in relation to conditions at a particular factory, should furnish a basis for estimating how efficiently equipment has been operated, the writer considers that attempting this for all factories is beyond the scope of the Synopsis.

Another criticism is that greater weight is frequently given the ranking indicated in this table than is justified by its accuracy. Without doubt, too literal an interpretation is frequently placed on data in this table, notwithstanding accompanying comments on the accuracy of the figures. This seems due to a widespread tendency to base inference as to the extent to which the available sugar in the cane has been recovered on some single figure. No method for calculating such a figure that has come to the writer's notice is free from defects. Such figures are valuable if used with due allowance for their probable accuracy, but the fact must be kept in mind that the reliability of conclusions based on them is limited. The writer does not wish to infer that reliable estimates of how closely the recovery approximates that possible with present processes cannot be made. On the contrary, given accurate control data, the writer believes that this can be quite closely estimated. Such estimates, however, involve the careful analysis of all available control data with due attention to factors such as those discussed under Chemical Control. The various factors involved are not readily expressed as a mathematical formula, and this has not been successfully accomplished in any formula that has come to the writer's notice.

Table 9 has been continued in the Synopsis because it serves a useful purpose in summarizing data submitted for the Synopsis and assigning an approximate standing to individual factories on the basis of the efficiency with which available sugar in the cane is recovered. While the factories are grouped substantially according to the quality of the results secured and a good general idea of the relative quality of work is conveyed, the ranking is hardly consistent enough to serve as a basis for close distinctions. If closer comparisons are desired, they must be based on analysis of all available control data. The writer trusts that this explanation will make the significance of this table clear.

The usual summary of losses is in Table 10.

Calculations in this Synopsis have been made by Mr. A. Brodie.

TABLE NO. 10

SUMMARY OF LOSSES

FACTORY	POUNDS POLARIZATION PER TON OF CANE					POLARIZATION PER 100 CANE					POLARIZATION PER 100 POLARIZATION OF CANE					Syrup Purity	FACTORY
	Bagasse	Press Cake	Molasses	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Undetermined	TOTAL		
H. C. & S. Co.	6.2	2.6	19.0	1.8	29.6	0.31	0.13	0.95	0.09	1.48	2.11	0.87	6.43	0.62	10.03	88.03	H. C. & S. Co.
Oahu	7.0	2.0	16.2	4.0	29.2	0.35	0.10	0.81	0.20	1.46	2.49	0.72	5.84	1.44	10.49	86.59	Oahu
Ewa	5.2	1.0	19.6	0.2	26.0	0.26	0.05	0.98	0.01	1.30	2.00	0.41	7.60	0.08	10.09	84.52	Ewa
Waialua	7.8	1.2	20.4	1.2	30.6	0.39	0.06	1.02	0.06	1.53	2.83	0.44	7.44	0.43	11.14	85.6	Waialua
Pioneer	7.2	1.8	17.6	1.0	27.6	0.36	0.09	0.88	0.05	1.38	2.48	0.66	6.06	0.36	9.56	86.64	Pioneer
Olaa	8.2	2.2	21.8	0.6	32.8	0.41	0.11	1.09	0.03	1.64	3.12	0.81	8.27	0.26	12.46	86.6	Olaa
Maui Agr.	12.4	...	22.2	—0.4	34.2*	0.62	...	1.11	—0.02	1.71*	4.06	...	7.23	—0.11	11.51*	87.60	Maui Agr.
Haw. Sug.	7.2	1.0	19.0	—2.0	25.2	0.36	0.05	0.95	—0.10	1.26	2.44	0.37	6.48	—0.67	8.63	88.34	Haw. Sug.
Lihue	8.0	1.8	18.2	2.6	30.6	0.40	0.09	0.91	0.13	1.53	3.18	0.72	7.29	1.04	12.23	83.7	Lihue
Onomea	3.0	0.4	16.4	0.4	20.2	0.15	0.02	0.82	0.02	1.01	1.28	0.13	6.76	0.19	8.36	86.28	Onomea
Hilo	4.4	0.8	17.8	2.2	25.2	0.22	0.04	0.89	0.11	1.26	1.81	0.29	7.31	0.93	10.34	85.73	Hilo
Honolulu	7.8	1.2	24.6	...	...	0.39	0.06	1.23	...	...	2.73	0.44	8.74	...	...	86.57	Honolulu
Haw. Agr.	7.6	1.0	20.6	2.6	31.8	0.38	0.05	1.03	0.13	1.59	3.18	0.46	8.62	1.04	13.30	85.29	Haw. Agr.
Kekaha	4.2	1.8	21.6	2.4	30.0	0.21	0.09	1.08	0.12	1.50	1.55	0.65	8.03	0.88	11.11	84.9	Kekaha
Hakalau	2.8	0.4	16.0	1.0	20.2	0.14	0.02	0.80	0.05	1.01	1.12	0.14	6.52	0.39	8.17	85.1	Hakalau
Wailuku	4.2	1.4	19.4	0.2	25.2	0.21	0.07	0.97	0.01	1.26	1.52	0.51	6.81	0.04	8.88	86.8	Wailuku
Makee	9.4	1.2	24.2	1.8	36.6	0.47	0.06	1.21	0.09	1.83	3.93	0.49	10.17	0.73	15.32	83.2	Makee
McBryde	7.6	0.6	23.0	1.6	32.8	0.38	0.03	1.15	0.08	1.64	2.84	0.25	8.56	0.59	12.24	85.23	McBryde
Honokaa	9.8	1.2	19.6	0.2	30.8	0.49	0.06	0.98	0.01	1.54	4.28	0.56	8.65	0.09	13.58	83.79	Honokaa
Laupahoehoe	7.6	0.8	17.6	3.0	29.0	0.38	0.04	0.88	0.15	1.45	2.90	0.33	6.83	1.15	11.21	87.75	Laupahoehoe
Hamakua	7.6	...	21.0	1.2	29.8	0.38	...	1.05	0.06	1.49	2.85	...	7.76	0.41	11.02	87.61	Hamakua
Pepeekeo	5.4	0.6	14.4	1.8	22.2	0.27	0.03	0.72	0.09	1.11	2.18	0.21	5.77	0.73	8.89	86.6	Pepeekeo
Kahuku	6.2	0.8	22.2	—2.2	27.0	0.31	0.04	1.11	—0.11	1.35	2.59	0.34	9.15	—0.94	11.14	81.50	Kahuku
Paauhau	6.2	0.4	18.0	1.0	25.6	0.31	0.02	0.90	0.05	1.28	2.53	0.15	7.29	0.42	10.39	85.76	Paauhau
Honomu	4.8	0.6	17.8	1.0	24.2	0.24	0.03	0.89	0.05	1.21	1.88	0.26	7.08	0.40	9.62	86.0	Honomu
Koloa	8.0	2.6	22.0	1.4	34.0	0.40	0.13	1.10	0.07	1.70	3.22	1.03	8.75	0.54	13.54	83.4	Koloa
Waiakea	12.4	1.2	24.4	1.2	39.2	0.62	0.06	1.22	0.06	1.96	4.63	0.46	9.17	0.46	14.72	86.23	Waiakea
Hutchinson	10.2	1.6	24.6	1.0	37.4	0.51	0.08	1.23	0.05	1.87	4.24	0.64	10.32	0.45	15.65	85.0	Hutchinson
Hawi	9.6	0.8	21.6	7.4	39.4	0.48	0.04	1.08	0.37	1.97	3.61	0.29	8.18	2.80	14.88	84.64	Hawi
Kaiwiki	10.4	1.8	18.8	3.6	34.6	0.52	0.09	0.94	0.18	1.73	3.85	0.68	6.98	1.35	12.86	87.92	Kaiwiki
Waianae	10.8	1.0	...	42.4	54.2	0.54	0.05	...	2.12	2.71	4.14	0.38	...	16.36	20.88	81.98	Waianae
Kohala	8.0	2.8	19.0	1.4	31.2	0.40	0.14	0.95	0.07	1.56	2.86	0.99	6.83	0.46	11.14	86.78	Kohala
Kilauea	6.0	2.2	25.4	3.2	36.8	0.30	0.11	1.27	0.16	1.84	2.73	0.95	11.41	1.42	16.51	79.9	Kilauea
Waimanalo	3.4	1.2	21.2	1.8	27.6	0.17	0.06	1.06	0.09	1.38	1.44	0.51	8.98	0.78	11.71	83.41	Waimanalo
Kaeleku	11.6	2.4	28.0	7.0	49.0	0.58	0.12	1.40	0.35	2.45	4.93	1.00	11.95	2.97	20.85	81.44	Kaeleku
Union Mill	13.8	2.2	23.0	1.0	40.0	0.69	0.11	1.15	0.05	2.00	5.55	0.87	9.20	0.38	16.00	86.3	Union Mill
Halawa	16.0	1.2	...	25.0	42.2	0.80	0.06	...	1.25	2.11	6.34	0.51	...	9.90	16.75	85.0	Halawa
Waimea	8.8	1.6	...	30.6	41.0	0.44	0.08	...	1.53	2.05	3.31	0.56	...	11.51	15.38	85.2	Waimea
Niulii	17.0	1.2	...	25.6	43.8	0.85	0.06	...	1.28	2.19	6.72	0.44	...	10.06	17.22	85.10	Niulii
Olowalu	6.6	1.6	18.8	17.4	44.4	0.33	0.08	0.94	0.87	2.22	2.38	0.56	6.73	6.17	15.84	84.9	Olowalu

* Sucrose.

ANNUAL SYNOPSIS OF MILL DATA—SHOWING RESULTS FROM 40 HAWAIIAN FACTORIES FOR CROP OF 1926

Factory	Factory No.	Milling Plant (Sizes in Inches)	Cane: Polarization	Cane: % Fiber	Cane: Tons per ton commercial sugar	Cane: Tons ground per hour	Cane: Tonnage ratio	Bagasse: Polarization	Bagasse: % Moisture	Bagasse: % Fiber	Bagasse: Pol. per 100 cane	Bagasse: Pol. per 100 pol. of cane	Bagasse: Pol. per 100 Fiber "Milling Loss"	Bagasse: Weight per 100 cane
H. C. & S. Co.**	6	K(4),2RC78(2),S72(2),12RM78(2)	14.83	11.75	7.28	66.74‡	1.90	1.51	41.48	56.48	0.31	2.11	2.67	20.82
Oahu	20	K(2),2RC78(2),S72(2),12RM78(2)	13.91	12.96	7.84	65.53‡	1.86	1.50	41.53	56.30	0.35	2.49	2.66	23.02
Ewa	5	K(2),2RC78,18RM78	12.93	12.14	8.35	84.31	1.71	1.16	43.77	54.39	0.26	2.00	2.13	22.32
Waialua	17	K(2),2RC78,12RM78	13.66	12.89	8.00	80.61	2.29	1.68	41.53	56.00	0.39	2.83	3.00	22.99
Pioneer	10	K,2RC72,S72,15RM72	14.46	12.96	7.48	78.39	2.18	1.48	43.97	53.68	0.36	2.48	2.76	24.14
Olaa	36	K,S72,12RM78	13.16	12.86	8.45	57.23	2.03	1.75	42.39	54.55	0.41	3.12	3.21	23.50
Maui Agr.**	21	K(2),3RC66,21RM66 *	15.37	12.27	7.16	84.75	2.43	2.49	47.53	48.85	0.62	4.06	5.10	25.11
Haw. Sug.	16	K,2RC72,S72,12RM78	14.65	12.55	7.28	50.27	1.43	1.63	40.63	57.25	0.36	2.44	2.85	21.92
Lihue	27	K,2RC78,S72,12RM78	12.48	11.84	8.91	66.85	1.90	1.84	42.45	54.86	0.40	3.18	3.35	21.58
Onomea	34	2RC60,S54,12RM66	12.10	12.86	8.78	46.25	1.83	0.73	38.39	60.40	0.15	1.28	1.21	21.30
Hilo	33	K,2RC60,12RM66	12.17	13.48	8.92	41.61	1.65	0.97	39.30	59.24	0.22	1.81	1.63	22.75
Honolulu	13	K(2),S54,2RC78,9RM78	14.12	12.01	8.11	43.26	1.54	1.85	39.71	57.71	0.39	2.73	3.21	20.83
Haw. Agr.††	30	3RC60,12RM66	11.96	12.84	9.39	46.30	1.84	1.68	40.90	56.84	0.38	3.18	2.96	22.66
Kekaha	25	2RC54,15RM60	13.47	11.72	8.11	40.12	1.60	1.06	38.84	59.36	0.21	1.55	1.78	19.75
Hakalau	7	2RC54,12RM9-60,3-66	12.30	12.51	8.55	31.93	1.53	0.67	37.93	61.12	0.14	1.12	1.10	20.47
Wailuku	2	K,2RC72,12RM78	14.17	11.66	7.54	41.59	1.18	1.10	38.93	59.49	0.21	1.52	1.84	19.60
Makee	14	K,2RC72,S72,9RM72	11.94	12.88	9.66	48.30	2.01	2.03	41.40	55.78	0.47	3.93	3.64	23.08
McBryde	12	K,2RC72,S72,9RM84	13.47	13.74	8.23	40.60	1.24	1.60	40.30	57.49	0.38	2.84	2.78	23.87
Honokaa††	35	K(2),2RC66,12RM66	11.35	12.65	9.88	39.77	1.58	2.00	44.85	52.31	0.49	4.28	3.82	24.20
Laupahoehoe	41	K,2RC54,9RM60	12.95	12.92	8.45	26.89	1.61	1.69	39.59	58.21	0.38	2.90	2.90	22.21
Hamakua**	15	K,2RC60,12RM60	13.46	14.41	8.14	31.25	1.50	1.46	43.15	54.75	0.38	2.85	2.67	26.33
Pepeekeo	19	2RC54,9RM60	12.45	12.52	8.58	27.05	1.62	1.34	36.42	61.89	0.27	2.18	2.17	20.33
Kahuku	43	K,2RC60,S54,9RM72	12.08	13.72	9.10	37.07	1.54	1.35	38.71	59.29	0.31	2.59	2.28	23.14
Paauhau††	24	2RC60,12RM66	12.35	12.94	8.78	30.11	1.19	1.43	38.73	59.23	0.31	2.53	2.41	21.85
Honomu	37	3RC60,9RM60	12.60	12.16	8.56	24.50	1.49	1.13	40.17	58.14	0.24	1.88	1.94	20.92
Koloa	38	K,2RC60,12RM66	12.59	14.01	8.97	34.44	1.37	1.63	41.09	56.33	0.40	3.22	2.89	24.88
Waiakea	3	K,2RC60,9RM60	13.29	14.09	8.56	25.68	1.54	2.37	42.50	54.24	0.62	4.63	4.37	25.99
Hutchinson††	31	2RC60,9RM60	11.97	11.23	9.65	31.53	1.89	2.61	38.61	57.78	0.51	4.24	4.52	19.43
Hawi	26	K,2RC54,12RM54	13.20	12.11	8.62	28.65	1.70	2.08	44.15	52.88	0.48	3.61	3.93	22.89
Kaiwiki	32	K,2RC60,9RM60	13.47	13.09	8.27	27.95	1.68	2.26	40.17	56.89	0.52	3.85	3.97	23.01
Waianae††	9	K(2),12RM60	12.97	14.51	9.41	26.36	1.58	2.07	41.22	55.81	0.54	4.14	3.71	26.00
Kohala	40	K(2),3RC60,9RM60	13.98	11.74	7.79	27.54	1.65	1.93	40.56	56.68	0.40	2.86	3.41	20.72
Kilauea††	23	K,S,3RC60,9RM60	11.17	10.95	10.49	25.4	1.52	1.55	41.83	55.69	0.30	2.73	2.78	19.66
Waimanalo	1	K,3RC54,9RM54	11.84	13.07	9.30	27.83	2.06	0.80	37.15	61.58	0.17	1.44	1.30	21.21
Kaeleku	47	K,2RC54,9RM60	11.69	13.88	10.43	30.59	1.83	2.30	41.44	55.39	0.58	4.93	4.15	25.06
Union Mill	11	K,9RM60	12.51	14.39	9.16	22.82	1.83	2.64	42.12	54.53	0.69	5.55	4.84	26.34
Halawa	29	K,2RC60,6RM50	12.62	13.73	9.22	14.04	1.62	3.28	39.51	56.22	0.80	6.34	5.84	24.43
Waimea	4	2RC48,12RM42	13.33	12.09	8.61	15.23	1.49	2.17	37.33	59.40	0.44	3.31	3.65	20.35
Niulii	39	K,9RM54	12.69	13.53	9.15	17.49	1.73	3.31	43.15	52.52	0.85	6.72	6.30	25.77
Olowalu	18	K,3RC48,9RM48	14.01	14.40	8.17	17.18	1.61	1.40	37.31	60.55	0.33	2.38	2.31	23.86
True Average, 1926			13.24	12.65	8.31	46.43	1.78	1.62	41.48	56.19	0.36	2.75	2.88	22.52
" " 1925			13.22	12.74	8.27	45.31	1.71	1.58	41.56	56.18	0.36	2.71	2.82	22.67
" " 1924			13.26	12.74	8.26	43.63	1.62	1.56	41.58	56.19	0.35	2.67	2.78	22.67
" " 1923			12.78	12.82	8.56	42.03	1.56	1.55	41.56	56.18	0.35	2.77	2.76	22.80
" " 1922			12.97	12.95	8.62	39.93	1.54	1.69	41.51	56.05	0.39	3.02	3.02	23.09
" " 1921			13.12	12.80	8.61	36.58	1.40	1.50	41.20	56.58	0.34	2.57	2.64	22.58
" " 1920			13.64	12.64	8.12	39.34	....	1.56	41.05	56.68	0.35	2.55	2.75	22.29
" " 1919			13.74	12.49	7.94	....	....	1.67	41.57	56.05	0.37	2.70	2.97	22.27
" " 1918			12.97	12.50	8.51	....	....	1.59	42.70	55.04	0.36	2.79	2.90	22.74
" " 1917			13.76	12.62	8.03	....	....	1.78	42.26	55.31	0.41	2.95	3.22	22.83

Factory No.	First Expressed Juice: Brix	FEJ: Polarization	FEJ: Purity	FEJ: Pol. of cane x 100 / Polarization	Mixed Juice: Brix	MJ: Polarization	MJ: Purity	MJ: Weight per 100 cane	MJ: Pol. per 100 cane	MJ: Pol. per 100 pol. of cane "Extraction"	Extraction Ratio	Last Expressed Juice: Polarization	LEJ: Purity	Maceration Water: Weight per 100 cane	Maceration Water: Dilution % normal juice
6	20.37	18.28	89.74	81.1	14.03	12.33	87.92	116.61	14.51	97.89	0.18	1.90	73.98	37.43	42.27
20	19.13	16.76	87.61	83.0	14.55	12.46	85.64	108.89	13.57	97.51	0.19	1.77	69.15	31.91	28.87
5	18.36	15.73	85.68	82.2	13.47	11.08	82.26	114.31	12.67	98.00	0.16	1.25	63.18	36.63	33.63
17	18.99	16.63	87.6	82.1	14.04	11.85	84.4	111.99	13.28	97.17	0.22	2.39	67.9	34.98	33.05
10	20.74	18.35	88.48	78.8	15.50	13.24	85.42	106.52	14.10	97.52	0.19	0.76	63.31	30.65	31.13
36	18.04	15.78	87.5	83.4	13.91	11.75	84.5	108.51	12.75	96.88	0.24	1.35	68.2	32.01	29.7
21	20.75	18.55	89.40	82.8	13.34	11.67	87.48	126.34	14.74	95.94	0.33	2.49	67.60	51.45	51.65
16	19.35	17.38	89.82	84.3	14.70	12.81	87.14	111.58	14.29	97.56	0.19	2.45	77.04	33.51	31.16
27	18.45	15.88	86.1	78.6	14.67	12.24	83.4	98.74	12.08	96.82	0.27	2.98	68.8	20.31	....
34	16.29	14.28	87.66	84.8	12.02	10.20	84.83	117.17	11.95	98.72	0.10	1.00	60.34	38.47	36.84
33	16.31	14.06	86.20	86.6	12.56	10.55	84.00	113.26	11.95	98.19	0.13	1.69	66.54	36.02	33.84
13	19.98	17.42	87.19	81.0	13.85	11.66	84.19	117.73	13.73	97.27	0.23	1.19	71.84	38.56	38.12
30	17.19	15.04	87.49	79.5	13.71	11.57	84.39	100.14	11.58	96.82	0.25	2.87	73.59	22.80	19.21
25	18.34	16.03	87.4	84.0	14.15	11.91	84.2	111.39	13.26	98.45	0.13	0.79	58.9	31.14	....
7	16.71	14.65	87.7	83.9	12.22	10.30	84.3	118.00	12.16	98.88	0.10	1.29	70.5	38.46	36.74
2	18.62	16.56	88.9	85.6	13.37	11.49	85.9	121.52	13.96	98.48	0.13	0.97	69.3	41.13	40.16
14	17.97	15.33	85.3	77.9	13.22	10.91	82.5	105.08	11.47	96.07	0.30	4.50	71.8	28.16	....
12	19.61	16.96	86.49	79.4	14.03	11.80	84.11	110.91	13.09	97.16	0.21	2.42	72.46	34.78	36.99
35	16.83	14.53	86.33	78.1	12.79	10.55	82.49	102.97	10.87	95.72	0.34	2.12	70.37	27.17	26.3
41	17.38	15.47	89.01	83.7	12.19	10.58	86.79	118.86	12.57	97.10	0.22	3.21	76.98	41.08	41.18
15	19.10	17.32	90.68	77.7	15.29	13.38	87.51	97.69	13.07	97.15	0.20	2.33	69.55	24.02	....
19	16.96	15.00	88.4	83.0	13.21	11.21	84.9	108.65	12.18	97.82	0.17	2.89	79.2	28.88	27.10
43	17.77	14.90	83.85	81.1	12.96	10.40	80.23	113.17	11.77	97.41	0.19	1.96	67.38	36.31	33.00
24	17.49	15.18	86.8	81.4	13.06	10.93	83.69	110.10	12.04	97.47	0.20	2.21	70.00	31.95	30.40
37	17.24	15.16	87.9	83.1	12.59	10.52	83.6	117.49	12.36	98.12	0.15	1.55	67.1	38.42	36.93
38	18.69	15.95	85.3	78.9	13.42	11.00	82.0	110.75	12.19	96.78	0.23	1.16	62.9	35.63	....
3	18.88	16.67	88.30	79.7	14.21	12.05	84.80	105.18	12.67	95.37	0.33	4.31	72.62	31.17	29.14
31	16.54	14.38	86.9	83.2	13.33	11.15	83.6	102.81	11.46	95.76	0.38	3.84	73.1	22.23	21.61
26	19.73	17.29	87.63	76.4	14.60	12.18	83.43	104.46	12.73	96.39	0.30	3.20	70.48	27.35	24.11
32	18.91	16.78	88.74	80.3	13.70	11.90	86.86	108.87	12.95	96.15	0.29	3.73	76.91	31.87	30.80
9	19.63	16.58	84.46	78.2	13.34	10.73	80.44	115.90	12.44	95.86	0.29	1.67	69.87	41.90	42.13
40	18.78	16.53	88.02	84.6	13.47	11.61	86.19	116.98	13.58	97.14	0.24	3.17	69.98	37.70	37.19
23	17.16	14.00	81.6	79.8	13.13	10.39	79.1	104.57	10.87	97.27	0.25	1.35	62.5	24.23	21.48
1	17.42	14.73	84.56	80.4	13.07	10.57	80.87	110.41	11.67	98.56	0.11	1.99	63.17	31.62	29.30
47	16.82	13.96	82.99	83.7	12.81	10.34	80.69	107.51	11.11	95.07	0.36	5.06	72.60	32.58	32.00
11	17.7	15.37	86.8	81.4	13.8	11.78	85.4	100.33	11.82	94.45	0.39	5.81	78.4	26.67	28.26
29	17.98	15.35	85.37	82.2	13.80	11.58	83.91	102.09	11.82	93.66	0.46	6.37	76.75	26.52	27.03
4	18.69	16.20	86.68	82.3	14.51	12.22	84.2	105.48	12.89	96.69	0.27	3.50	71.40	25.83	24.95
39	17.75	15.42	86.87	82.3	14.93	12.56	84.10	94.28	11.84	93.28	0.50	6.25	76.41	20.05	17.68
18	20.12	17.70	88.0	79.2	13.95	11.67	83.7	117.27	13.68	97.62	0.17	3.46	65.3	41.13	40.87
1926	18.52	16.20	87.45	81.73	13.68	11.58	84.64	111.09	12.88	97.25	0.22	2.08	69.04	33.61	....
1925	18.42	16.19	87.92	81.64	13.60	11.59	85.20	110.96	12.86	97.29	0.21	1.94	69.71	33.63	....
1924	18.51	16.26	87.86	81.55	13.52	11.50	85.05	112.23	12.91	97.33	0.21	1.96	71.62	34.90	....
1923	18.09	15.75	87.05	81.1	13.13	11.06	84.27	112.32	12.42	97.23	0.22	1.79	68.31	35.12	....
1922	18.14	16.01	86.84	81.0	13.46	11.27	83.73	111.48	12.58	96.98	0.23	1.93	69.13	34.75	....
1921	18.74	16.16	86.22	81.2	13.25	10.97	82.77	116.50	12.79	97.43	0.20	1.68	65.89	39.30	....
1920	19.32	16.85	87.24	80.9	13.48	11.31	83.87	117.35	13.29	97.45	0.20	1.65	68.20	39.95	....
1919	19.17	16.74	87.34	82.0	13.39	11.29	84.29	118.29	13.37	97.30	0.22	1.70	68.53	40.80	....
1918	18.26	15.92	87.18	81.3	12.92	10.85	83.99	116.05	12.60	97.21	0.22	1.56	69.52	38.99	....
1917	19.14	16.85	88.02	81.6	13.48	11.45	84.88	116.53	13.34	97.05	0.23	1.71	71.15	39.39	....

Factory No.	Clarified juice purity	Syrup: Brix	Syrup: Purity	Syrup: Increase in Purity	Press Cake: Polarization	Press Cake: Weight per 100 cane	Press Cake: Pol. per 100 cane	Press Cake: Pol. per 100 pol. of cane	Lime Used (Weight Per 100 Cane): In Juice	Lime: In Settlings	Lime: Total	Commercial Sugar: Polarization	CS: % Moisture	CS: Weight per 100 cane	CS: Pol. per 100 cane	CS: Pol. per 100 pol. of cane	CS: Pol. per 100 pol. of juice	CS: Total weight in thousand tons
6	87.92	64.10	88.03	0.11	4.95	2.60	0.13	0.87	0.09	....	0.09	97.05	0.80	13.74	13.34	89.96	91.91	64
20	86.66	66.12	86.59	0.95	4.27	2.35	0.10	0.72	0.05	0.02	0.07	97.58	0.58	12.76	12.45	89.51	91.80	62
5	83.68	68.30	84.52	2.26	1.98	2.66	0.05	0.41	0.07	0.01	0.08	97.09	0.63	11.97	11.62	89.91	91.75	52
17	85.7	64.66	85.6	1.2	2.10	2.88	0.06	0.44	....	....	0.10	97.17	0.75	12.49	12.14	88.86	91.45	44
10	86.41	66.70	86.64	1.22	2.49	3.81	0.09	0.66	0.06	0.01	0.07	97.88	0.47	13.36	13.08	90.44	92.73	29
36	86.6	62.43	86.6	2.1	6.08	1.74	0.11	0.81	....	....	0.08	97.38	0.67	11.83	11.52	87.54	90.36	36
21	87.48	66.06	87.60	0.12‖	....	....	....	....	0.05	....	0.05	97.77‖	0.57	13.96	13.66	88.82	92.59	42
16	88.05	66.82	88.34	1.20	2.22	2.45	0.05	0.37	0.05	0.01	0.06	97.50	0.61	13.73	13.38	91.37	93.66	30
27	83.8	63.75	83.7	0.3	3.49	2.58	0.09	0.72	....	....	0.14	97.62	0.67	11.22	10.95	87.77	90.65	30
34	85.75	66.44	86.28	1.45	0.60	2.60	0.02	0.13	0.07	....	0.07	97.38	0.75	11.39	11.09	91.64	92.83	26
33	85.37	69.80	85.73	1.73	1.26	2.83	0.04	0.29	0.05	....	0.05	97.36	0.75	11.21	10.91	89.66	91.32	25
13	87.07	61.04	86.57	2.38¶	2.11	2.91	0.06	0.44	....	....	0.09	....	....	....	....	....	....	28†
30	85.33	60.65	85.29	0.90	1.90	2.88	0.05	0.46	0.10	....	0.10	97.42	0.70	10.65	10.37	86.70	89.55	21§
25	85.2	63.91	84.9	0.7	3.20	2.72	0.09	0.65	0.08	....	0.08	97.16	0.69	12.33	11.98	88.89	90.29	22
7	84.9	66.35	85.1	0.8	0.65	2.71	0.02	0.14	0.05	....	0.05	96.49	0.95	11.70	11.29	91.82	92.86	20§
2	86.9	64.97	86.8	0.9	2.61	2.78	0.07	0.51	0.14	....	0.14	97.34	0.63	13.27	12.91	91.12	92.52	17
14	83.4	58.96	83.2	0.7	2.24	2.64	0.06	0.49	0.06	0.03	0.09	97.62	0.69	10.35	10.11	84.68	88.14	18
12	84.62	61.95	85.23	1.12	2.10	1.58	0.03	0.25	0.03	0.04	0.07	97.26	0.62	12.15	11.82	87.76	90.33	16
35	83.88	60.64	83.79	1.30	2.67	2.30	0.06	0.56	0.06	0.02	0.08	96.96	0.65	10.12	9.81	86.42	90.28	20§
41	87.75	63.92	87.75	0.96	2.18	1.95	0.04	0.33	0.06	....	0.06	97.16	0.65	11.83	11.50	88.79	91.44	14§
15	87.51	52.13	87.61	0.10	....	....	....	....	0.07	....	0.07	97.44	0.67	12.29	11.97	88.98	91.59	14
19	86.5	68.17	86.6	1.7	1.16	2.22	0.03	0.21	0.07	....	0.07	97.35	0.56	11.65	11.34	91.11	93.14	13
43	81.89	61.12	81.50	1.27	1.39	2.92	0.04	0.34	0.06	0.01	0.07	97.72	0.54	10.98	10.73	88.86	91.22	14
24	85.8	68.97	85.76	2.07¶	0.78	2.34	0.02	0.15	0.04	0.01	0.05	97.22	0.52	11.38	11.07	89.61	91.94	14
37	85.2	72.57	86.0	2.4	1.14	2.87	0.03	0.26	....	....	0.07	97.48	0.50	11.68	11.39	90.38	92.12	11
38	83.3	62.26	83.4	1.4	3.30	3.95	0.13	1.03	0.10	0.09	0.19	97.62	0.61	11.15	10.89	86.46	89.33	10
3	85.72	50.48	86.23	1.43¶	2.54	2.43	0.06	0.46	....	....	0.10	97.04	0.79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	85.5	67.90	85.0	1.4	2.67	2.87	0.08	0.64	0.09	0.01	0.10	97.39	0.74	10.37	10.10	[illegible]	[illegible]	[illegible]
26	83.82	61.78	84.64	1.21	1.12	3.46	0.04	0.29	0.08	....	0.08	96.84	0.87	11.61	11.24	[illegible]	[illegible]	[illegible]
32	88.09	59.95	87.92	1.04	4.09	2.24	0.09	0.68	0.08	....	0.08	[illegible]	[illegible]	[illegible]	11.74	[illegible]	[illegible]	[illegible]
9	82.39	63.04	81.98	1.54	2.10	2.37	0.05	0.38	0.04	0.01	0.05	96.54	0.77	[illegible]	10.26	79.12	82.54	5
40	87.19	61.03	86.78	0.59	3.70	3.76	0.14	0.99	0.12	....	0.12	96.78	0.66	12.84	12.42	88.86	91.48	7
23	79.9	61.30	79.9	0.8	4.45	2.38	0.11	0.95	0.08	....	0.08	97.78	0.65	9.54	9.33	83.49	85.83	6§
1	83.33	61.72	83.41	2.54	2.02	2.97	0.06	0.51	0.07	0.02	0.09	97.21	0.62	10.76	10.46	88.29	89.58	8
47	81.40	52.31	81.44	0.75¶	5.15	2.26	0.12	1.00	0.05	....	0.05	96.49	....	9.59	9.25	79.15	83.26	6
11	85.6	57.9	86.3	0.9	3.92	2.79	0.11	0.87	0.08	0.01	0.09	96.30	1.28	10.91	10.51	84.00	88.93	6
29	84.62	57.30	85.0	1.09¶	2.20	2.90	0.06	0.51	0.06	0.01	0.07	96.90	0.90	10.85	10.51	83.25	88.89	3
4	84.6	61.82	85.2	1.0 ¶	2.97	2.52	0.08	0.56	0.06	0.01	0.07	97.17	....	11.61	11.28	84.62	87.51	3
39	84.89	55.18	85.10	1.00	2.82	2.00	0.06	0.44	0.05	....	0.05	96.10	1.25	10.93	10.50	82.78	88.74	4
18	84.9	63.69	84.9	1.2	2.86	2.76	0.08	0.56	0.13	0.03	0.16	96.38	....	12.24	11.79	84.16	86.21	2
1926	85.67	64.04	85.78	1.14	2.67	2.47	0.07	0.50	....	....	0.081	97.30	0.68	12.03	11.71	88.62	91.13	782
1925	86.15	63.65	86.27	1.07	2.28	2.23	0.05	0.38	....	....	0.079	97.22	0.75	12.10	11.76	89.11	91.59	767
1924	86.18	63.32	86.32	1.27	2.26	2.16	0.05	0.37	....	....	0.086	97.18	0.75	12.11	11.77	88.94	91.39	696
1923	85.37	63.26	85.65	1.38	2.31	2.22	0.05	0.40	....	....	0.087	96.90	0.83	11.69	11.33	88.77	91.28	532
1922	84.74	63.37	84.96	1.23	2.57	2.65	0.07	0.53	....	....	0.084	96.88	0.87	11.61	11.24	87.02	89.68	558
1921	83.74	62.09	83.90	1.13	1.66	2.58	0.04	0.33	....	....	0.074	96.75	0.92	11.62	11.24	85.86	88.03	502
1920	85.03	61.34	85.20	1.33	1.65	2.63	0.04	0.31	....	....	0.071	96.36	0.97	12.32	11.87	87.35	89.56	547
1919	85.46	62.42	85.70	1.41	1.34	2.32	0.03	0.22	....	....	0.076	96.34	0.96	12.59	12.13	88.57	90.96	590
1918	85.36	61.66	85.78	1.79	1.48	2.36	0.03	0.26	....	....	0.072	96.53	0.94	11.75	11.34	87.91	90.37	557
1917	86.08	62.28	86.36	1.48	1.52	2.28	0.03	0.25	....	....	0.063	96.87	0.87	12.45	12.06	87.93	90.58	[illegible]

Factory No.	Final Molasses: Weight per 100 cane	FM: Sucrose per 100 cane	FM: Sucrose per 100 pol. of cane	FM: Sucrose per 100 pol. of juice	FM: Gravity solids	FM: Gravity purity	FM: True purity	Undetermined Losses: Pol. per 100 cane	Undetermined Losses: Pol. per 100 pol. of cane	Factory No.	Factory
6	2.75	0.95	6.43	6.57	86.71	39.94	....	0.09	0.62	6	H. C. & S. Co.**
20	2.36	0.81	5.84	5.99	90.85	37.94	....	0.20	1.44	20	Oahu
5	3.06	0.98	7.60	7.75	90.34	35.51	....	0.01	0.08	5	Ewa
17	2.81	1.02	7.44	7.65	93.72	38.5	....	0.06	0.43	17	Waialua
10	2.70	0.88	6.06	6.22	90.96	35.69	....	0.05	0.36	10	Pioneer
36	3.14	1.09	8.27	8.53	88.26	39.3	....	0.03	0.26	36	Olaa
21	3.05	1.11	7.23	7.53	91.27	39.88	....	—0.02	—0.11	21	Maui Agr.**
16	2.94	0.95	6.48	6.65	87.94	36.71	....	—0.10	—0.67	16	Haw. Sug.
27	2.86	0.91	7.29	7.53	90.30	35.2	....	0.13	1.04	27	Lihue
34	2.50	0.82	6.76	6.85	90.48	36.22	43.26	0.02	0.19	34	Onomea
33	2.75	0.89	7.31	7.44	86.81	37.32	....	0.11	0.93	33	Hilo
13	3.48	1.23	8.74	8.99	93.67	37.92	....	....	....	13	Honolulu
30	3.00	1.03	8.62	8.90	87.80	39.19	....	0.13	1.04	30	Haw. Agr.
25	3.22	1.08	8.03	8.16	88.20	38.12	....	0.12	0.88	25	Kekaha
7	2.66	0.80	6.52	6.60	85.43	35.32	....	0.05	0.39	7	Hakalau
2	2.67	0.97	6.81	6.91	93.55	38.66	....	0.01	0.04	2	Wailuku
14	3.49	1.21	10.17	10.59	91.21	38.11	....	0.09	0.73	14	Makee
12	3.50	1.15	8.56	8.81	89.41	36.82	....	0.08	0.59	12	McBryde
35	3.12	0.98	8.65	9.04	83.45	37.71	....	0.01	0.09	35	Honokaa††
41	2.45	0.88	6.83	7.04	88.91	40.57	....	0.15	1.15	41	Laupahoehoe
15	2.84	1.05	7.76	7.99	85.85	42.78	....	0.06	0.41	15	Hamakua**
19	2.31	0.72	5.77	5.90	92.50	33.64	38.6	0.09	0.73	19	Pepeekeo
43	3.42	1.11	9.15	9.39	93.34	34.65	....	—0.11	—0.94	43	Kahuku
24	2.80	0.90	7.29	7.48	86.06	37.30	....	0.05	0.42	24	Paauhau††
37	2.73	0.89	7.08	7.21	91.15	35.8	....	0.05	0.40	37	Honomu
38	3.46	1.10	8.75	9.04	86.95	36.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	....	....	....	....	87.25	41.12	43.53	2.12	16.36	[illegible]	[illegible]
40	2.71	0.95	6.83	7.03	93.47	37.72	....	0.07	0.46	[illegible]	[illegible]
23	3.89	1.27	11.41	11.73	87.64	37.39	....	0.16	1.42	[illegible]	[illegible]
1	2.98	1.06	8.98	9.11	92.91	38.39	....	0.09	0.78	1	Waimanalo
47	3.77	1.40	11.95	12.57	91.08	40.67	....	0.35	2.97	47	Kaeleku
11	3.03	1.15	9.20	9.74	88.9	42.77	48.5	0.05	0.38	11	Union Mill
29	....	....	....	....	87.0	40.0	....	1.25	9.90	29	Halawa
4	....	....	....	....	....	....	....	1.53	11.51	4	Waimea
39	....	....	....	....	....	....	....	1.28	10.06	39	Niulii
18	2.73	0.94	6.73	6.89	89.57	38.52	....	0.87	6.17	18	Olowalu
1926	2.93	0.99	7.51	7.72	89.41	37.97	....	0.11	0.60	[illegible]	
1925	2.79	0.94	7.07	7.26	89.75	37.32	....	0.11	[illegible]	[illegible]	
1924	2.90	0.98	7.41	7.62	88.81	38.16	....	0.11	0.61	[illegible]	
1923	2.89	0.97	7.58	7.79	88.53	37.90	....	0.08	0.48	[illegible]	
1922	3.11	1.06	8.16	8.41	87.91	38.75	....	0.21	1.27	[illegible]	
1921	3.63	1.22	9.27	9.51	87.12	38.53	....	0.28	1.97	1921	
1920	3.24	1.10	8.03	8.24	87.42	38.75	....	....	....	1920	
1919	3.02	1.00	7.24	7.42	87.34	37.95	....	....	....	1919	
1918	3.04	1.04	7.96	8.17	87.32	39.07	....	....	....	1918	
1917	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	....	....	1917	

* Mill in process of reconstruction; 28% of crop 15 rollers only.
‖ Sucrose.
† Refined sugar.
‡ For one mill only.
¶ Probably influenced by low grade sugar in syrup.
§ 1926 crop unfinished.
** Petree process.
†† Balance of 1925 crop included.

CANE MILL DATA, SEASON OF 1926

Factory	Factory No.	MILLING PLANT (Sizes in Inches)	REVOLVING KNIVES								MILL OPENINGS											Factory No.	SPEED OF ROLLERS—FEET PER MINUTE							PRESSURE ON ROLLERS—TONS							Tons Cane per Hour	Tonnage Ratio	Factory No.	Factory
			First Set				Second Set				Crusher	1st Mill		2nd Mill		3rd Mill		4th Mill		5th Mill			Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill	Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill				
			Number	Distance Apart Inches	Distance from Conveyor Inches	Revolutions per Minute	Number	Distance Apart Inches	Distance from Conveyor Inches	Revolutions per Minute		Front	Back	Front	Back	Front	Back	Front	Back	Front	Back																			
H. C. & S. Co.	6	K(2),2RC34x78,S72,12RM34x78	28	9 3/4	24	1,200	56	5	16	1,200	1/16	7/16	1/16	5/16	1/32	5/16	0	7/16	0	....	....	6	30	25	24	30.2	24	....	....	300	400	375	460	460	...	...	66.74*	1.90	6	H. C. & S. Co.
" "	6	K(2),2RC34x78,S72,12RM34x78	28	9 3/4	24	1,200	56	5	16	1,200	1/16	7/16	1/16	5/16	1/32	5/16	0	7/16	0	....	....	6	30	25	24	30.2	24	....	....	300	400	375	460	460	...	...			6	" "
Oahu	20	K,2RC34x78,S72,12RM34x78	28	5 1/2	18	490	..	....	....	....	1/8	3/8	0	5/8	0	1/2	0	3/8	0	....	....	20	35.5	24.4	20.3	22.7	24.4	....	....	313	532	501	470	532	...	...	65.53*	1.86	20	Oahu
"	20	K,2RC34x78,S72,12RM34x78	28	5 1/2	18	690	..	....	....	....	1/8	5/16	0	5/8	0	1/2	0	3/8	0	....	....	20	33.8	23.2	21.1	23.7	25.5	....	....	256	615	330	379	456	...	...			20	"
Ewa	5	K(2),2RC33x78,18RM34x78	72	1	14	580	72	1	2	580	1/2	3/4	1/8	3/4	1/8	3/4	1/8	5/8	1/16	5/8	1/16†	5	22.7	21.1	24.1	25.8	26.4	30.2	34.5	313	437	476	439	416	441	475	84.31	1.71	5	Ewa
Waialua	17	K(2),2RC33x78,12RM34x78	72	1 7/8	16	580	72	1 7/8	2 1/2	580	1 1/4	1/4	0	1/4	0	3/16	0	3/16	0	....	....	17	29.9	28.1	24.6	28	30.2	....	....	300	480	480	500	500	...	...	80.61	2.29	17	Waialua
Pioneer	10	K,2RC34x72,S72,15RM34x72	27	2 1/4	16	690	..	....	....	....	3/16	1/2	1/16	7/16	1/16	7/16	1/16	7/16	0	7/16	0	10	51.9	30.1	31.3	28.1	28.1	31.4	....	294	485	428	347	344	367	...	78.39	2.18	10	Pioneer
Olaa	36	K,S72,12RM34x78	36	3 13/16	4 1/2	450	..	....	....	....	....	1	3/16	11/16	1/8	7/16	0	5/16	0	....	....	36	...	21.4	24.5	28.5	32.2	....	....	...	350	320	350	405	...	...	57.23	2.03	36	Olaa
Maui Agr ‡	21	K(2),3RC34x66,21RM34x66	..	.....	....	....	..	....	....	....	....	...	...	....	....	....	....	....	....	....	....	21	...	...	...	....	....	....	....	...	...	...	...	...	...	...	84.75	2.43	21	Maui Agr.
Haw. Sug.	16	K,2RC28x72,S72,12RM34x78	32	4	15	450	..	....	....	....	1/4	9/16	1/16	3/8	0	5/16	0	1/4	0	....	....	16	28	17.6	19.8	19.6	21.1	....	....	300	498	490	490	502	...	...	50.27	1.43	16	Haw. Sug.
Lihue	27	K,2RC34x78,S72,12RM34x78	10	7	10	350	..	....	....	....	1/16	5/8	1/16	7/16	0	3/8	0	1/4	0	....	....	27	38.9	23	23	24.9	28	....	....	290	470	410	430	460	...	...	66.85	1.90	27	Lihue
Onomea	34	2RC28x60,S54,12RM32x66	..	.....	....	....	..	....	....	....	5/16	1/2	1/16	3/8	0	3/8	0	1/4	0	....	....	34	29.8	21.7	21.3	21.6	21.8	....	....	...	428	420	400	420	...	...	46.25	1.83	34	Onomea
Hilo	33	K(2),3RC34x66,18RM34x66	10	6	10	200	..	....	....	....	1/4	5/8	1/32	1/4	0	3/16	0	3/8	0	....	....	33	34.9	24.5	23.3	26.4	14.7	....	....	...	395	395	395	430	...	...	41.61	1.65	33	Hilo
Honolulu	13	K(2),S54,2RC33x78,9RM34x78	24	6	18	450	24	6	4	450	1/8	1/2	1/2	3/8	0	1/4	0	....	....	....	....	13	19.7	18.6	21.2	21.8	....	....	....	250	450	420	420	...	...	...	43.26	1.54	13	Honolulu
Haw. Agr.	30	3RC32x60,12RM32x66	..	.....	....	....	..	....	....	....	1x5/8	3/4	1/8	5/8	1/16	9/16	0	5/16	0	....	....	30	21.5	20	17.5	19.5	21.7	....	....	355	384	457	279	440	...	...	46.30	1.84	30	Haw. Agr.
Kekaha	25	2RC24x54,15RM32x60	..	.....	....	....	..	....	....	....	7/8	7/8	1/4	11/16	1/8	5/8	1/16	1/2	1/16	1/2	1/32	25	21	16	17.7	19	20	20	....	...	320	315	348	328	356	...	40.12	1.60	25	Kekaha
Hakalau	7	2RC24x54,12RM9-32x60,3-32x66	..	.....	....	....	..	....	....	....	1/4	3/4	0	1/4	0	1/8	0	1/4	0	....	....	7	30.5	21.6	24.2	26.5	15.8	....	....	...	322	322	345	380	...	...	31.93	1.53	7	Hakalau
Wailuku	2	K,2RC28x72,12RM34x78	10	6	18	400	..	....	....	....	1/16	3/8	1/16	3/8	0	5/16	0	3/16	0	....	....	2	30.3	19.5	16.8	17.3	22.3	....	....	...	400	370	360	380	...	...	41.59	1.18	2	Wailuku
Makee	14	K,2RC34x72,S72,9RM34x72	12	6	30	150	..	....	....	....	0	7/16	0	3/8	0	3/8	0	....	....	....	....	14	25.9	22.5	25.7	29.5	....	....	....	250	450	475	475	...	...	...	48.30	2.01	14	Makee
McBryde	12	K,2RC34x72,S72,9RM34x84	24	8	16	400	..	....	....	....	1/4	7/16	0	3/8	0	1/4	0	....	....	....	....	12	26	18	18	18	....	....	....	250	450	495	520	...	...	...	40.60	1.24	12	McBryde
Honokaa	35	K(2),2RC30x66,12RM32x66	16	12	16	400	39	4	5 1/2	500	5/8	1/2	1/16	3/8	0	5/16	0	1/4	0	....	....	35	30.2	21.6	18.2	22.1	24.4	....	....	170	324	316	316	359	...	...	39.77	1.58	35	Honokaa
Laupahoehoe	41	K,2RC30x54,9RM32x60	16	3 3/4	1	450	..	....	....	....	7/16	3/8	0	3/16	0	1/8	0	....	....	....	....	41	19.6	20.9	18.8	20.9	....	....	....	250	374	374	374	...	...	...	26.89	1.61	41	Laupahoehoe
Hamakua	15	K,2RC30x60,12RM32x60	32	3 1/2	2	400	..	....	....	....	1/4	1/2	0	1/2	0	3/8	0	3/16	0	....	....	15	30.5	19.7	19.7	20.1	24.2	....	....	...	380	370	370	400	...	...	31.25	1.50	15	Hamakua
Pepeekeo	19	2RC24x54,9RM32x60	..	.....	....	....	..	....	....	....	0	1/2	0	3/32	0	3/32	0	....	....	....	....	19	31.4	17.9	19.7	21.6	....	....	....	...	380	380	380	...	...	...	27.05	1.62	10	Pepeekeo
Kahuku	43	K,2RC30x60,S54,9RM34x72	10	5 1/2	25 1/2	430	..	....	....	....	7/16	5/16	1/16	3/16	1/32	1/4	0	....	....	....	....	43	22.7	15.4	17.6	20.3	....	....	....	180	430	420	490	...	...	...	37.07	1.54	43	Kahuku
Paauhau	24	2RC26x60,12RM32x66	..	.....	....	....	..	....	....	....	0	3/8	0	1/4	0	3/16	0	1/8	0	....	....	24	23.6	14.5	16.9	18.8	20.7	....	....	...	396	394	358	406	...	...	30.11	1.19	24	Paauhau
Honomu	37	3RC34x60,9RM32x60	..	.....	....	....	..	....	....	....	1/2x0	3/8	0	3/16	0	3/16	0	....	....	....	....	37	21.1	18.6	21.4	23.8	....	....	....	295	318	318	318	...	...	...	24.80	1.49	37	Honomu
Koloa	38	K,2RC27x60,12RM32x66	12	4 1/2	8	300	..	....	....	....	1/16	3/4	1/16	9/16	1/32	7/16	0	7/16	0	....	....	38	24.8	17.3	19	17.6	19.5	....	....	140	400	390	400	380	...	...	34.44	1.37	38	Koloa
Waiakea	3	K,2RC27x60,9RM32x60	38	6	4 1/2	380	..	....	....	....	0	7/16	0	5/32	0	3/32	0	....	....	....	....	3	23	16	17.6	19.6	....	....	....	170	320	348	370	...	...	...	25.68	1.54	3	Waiakea
Hutchinson	31	2RC30x60,9RM32x60	..	.....	....	....	..	....	....	....	1/2	1/2	0	3/16	0	1/8	0	....	....	....	....	31	27.6	17.2	19.2	21.2	....	....	....	65	420	400	400	...	...	...	31.53	1.89	31	Hutchinson
Hawi	26	K,2RC29x54,12RM30x54	22	4 3/4	9	625	..	....	....	....	3/8	7/16	0	3/8	0	1/8	0	1/16	0	....	....	26	34	24.8	23.2	26	26	....	....	117	261	326	288	273	...	...	28.65	1.70	26	Hawi
Kaiwiki	32	K,2RC24x60,9RM32x60	18	3	2	350	..	....	....	....	3/16	7/16	0	1/4	0	1/4	0	....	....	....	....	32	22.3	17.7	19.8	22.4	....	....	....	...	354	330	354	...	...	...	27.95	1.68	32	Kaiwiki
Waianae	9	K(2),12RM9-30x60,3-32x60	36	2 1/2	10	400	36	2 1/2	4	400	....	1/2	1/4	1/2	0	3/8	0	1/4	0	....	....	9	...	16.7	16.7	16.7	17.2	....	....	...	287	291	291	340	...	...	26.36	1.58	9	Waianae
Kohala	40	K(2),3RC30x60,9RM32x60	12	4	18	375	36	1 1/2	1 1/2	400	5/8x3/8	3/8	0	1/4	0	3/16	0	....	....	....	....	40	25	18	20	25	....	....	....	...	350	340	360	...	...	...	27.54	1.65	40	Kohala
Kilauea	23	K,S,3RC32x60,9RM32x60	10	6	2	250	..	....	....	....	5/16x1/8	5/16	0	3/16	0	1/16	0	....	....	....	....	23	18	19.5	26.5	20.5	....	....	....	300	320	310	312	...	...	...	25.4	1.52	23	Kilauea
Waimanalo	1	K,3RC32x54,9RM30x54	28	1 7/8	3 1/2	514	..	....	....	....	5/8x1/8	5/16	0	1/4	0	3/16	0	....	....	....	....	1	18.9	18.4	18	18	....	....	....	348	348	348	348	...	...	...	27.83	2.06	1	Waimanalo
Kaeleku	47	K,2RC24x54,9RM32x60	9	6	8	250	..	....	....	....	0	7/8	0	1/4	0	1/8	0	....	....	....	....	47	19.8	16.6	18	20.4	....	....	....	...	340	340	340	...	...	...	30.59	1.83	47	Kaeleku
Union Mill	11	K,9RM30x60	16	4	6	400	..	....	....	....	....	5/8	1/8	1/4	0	1/4	0	....	....	....	....	11	...	13	17.4	16.3	....	....	....	...	262	295	300	...	...	...	22.82	1.83	11	Union Mill
Halawa	29	K,2RC30x60,6RM26x50	20	4 1/2	7/8	400	..	....	....	....	3/16	5/16	0	1/8	0	....	....	....	....	....	....	29	15.7	17	11.7	....	....	....	....	160	152	224	...	...	...	...	14.04	1.62	29	Halawa
Waimea	4	2RC24x48,12RM26x42	..	.....	....	....	..	....	....	....	0	1/2	1/8	7/16	0	1/4	0	1/4	0	....	....	4	20.4	13.6	14.1	13.6	17	....	....	...	215	...	154	154	...	...	15.23	1.49	4	Waimea
Niulii	39	K,9RM30x54	9	6	3 1/4	525	..	....	....	....	....	3/8	1/32	5/32	1/64	1/8	0	....	....	....	....	39	...	18.3	21.3	21.8	....	....	....	...	199	212	196	...	...	...	17.49	1.73	39	Niulii
Olowalu	18	K,3RC28x48,9RM27x48	16	3	3	400	..	....	....	....	3/8x0	5/16	0	1/4	0	1/4	0	....	....	....	....	18	23.1	23.1	26.1	26.1	....	....	....	200	200	220	220	...	...	...	17.18	1.61	18	Olowalu

*Tons of cane per hour for one tandem.
†6th Mill. Openings ⅜x0, returner bar from top roller 1¼, 1½, 1¾.
‡Mill in process of reconstruction, 28 per cent of crop 15 rollers only.

Sugar Prices

96° Centrifugals for the Period September 20 to December 13, 1926

Date	Per Pound	Per Ton	Remarks
Sept. 20, 1926	4.52¢	$ 90.40	Cubas.
" 23	4.535	90.70	Cubas, 4.55; Porto Ricos, 4.52.
" 24	4.52	90.40	Cubas.
" 28	4.63	92.60	Philippines, 4.61; Cubas, 4.65.
" 29	4.65	93.00	Spot Cubas.
Oct. 4	4.61	92.20	Cubas.
" 7	4.65	93.00	Cubas.
" 11	4.58	91.60	Cubas.
" 14	4.55	91.00	Cubas, 4.52, 4.58.
" 20	4.52	90.40	Cubas.
" 22	4.58	91.60	Cubas.
" 26	4.52	90.40	Cubas.
Nov. 4	4.58	91.60	Cubas.
" 11	4.55	91.00	Cubas.
" 12	4.58	91.60	Cubas.
" 17	4.61	92.20	Cubas.
" 18	4.71	94.20	Cubas, 4.65, 4.77.
" 19	4.83	96.60	Cubas.
" 20	4.865	97.30	Cubas, 4.83, 4.90.
" 22	4.90	98.00	Cubas.
Dec. 2	5.01	100.20	——— 5.02, 5.00.
" 3	5.02	100.40	Cubas.
" 6	5.15	103.00	Porto Ricos.
" 8	5.08	101.60	Cubas.
" 13	5.15	103.00	Cubas.